Environmental Quality

Along the American River

The 1996 Report of the
Council on Environmental Quality

Environmental Quality

Along the American River

Printed on Recycled Paper

I

This report will be available on the White House web site (http://www.whitehouse.gov/CEQ).

II

TABLE OF CONTENTS

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IV

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TO THE CONGRESS OF THE UNITED STATES

I am pleased to transmit to the Congress the 1996 Annual Report on Environmental Quality.

This edition of Environmental Quality, entitled *Along the American River*, celebrates our rich natural heritage and the many efforts underway to preserve and restore it. A nation's destiny is bound intimately to its natural endowment—its coasts, its mountains, its forests and, of course, its rivers.

We can trace our very history along our rivers. They gave rise to our great cities, they nourish our farms, and they connect our communities one to another. How we care for our rivers—indeed, how we care for all that nature has bestowed upon us—determines the legacy we leave future generations.

In times past our rivers suffered, but today they are being born anew. Across the country, communities are reconnecting with their rivers, restoring them to health, and discovering fresh economic opportunity in their renewal. This river renaissance exemplifies a new spirit taking hold in America—a recognition that a strong economy and a healthy environment go hand in hand.

I am proud of all that my Administration has done to encourage and support these efforts. I'm especially proud of our American Heritage Rivers Initiative, which helps communities restore their rivers and riverfronts, and our Clean Water Action Plan, which provides new tools and resources to clean our rivers, lakes, and coastal waters.

Americans want a clean, healthy environment and are willing to work hard to achieve that end. We can all take pride in our many accomplishments, even as we dedicate ourselves to meeting the challenges still ahead.

I invite you to join me on this river journey, celebrating our past, and charting a new course for our future.

William J. Clinton

THE WHITE HOUSE

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STATEMENT FROM THE CHAIR

Something remarkable is happening along California's Napa River.

Twenty-seven times in the last 150 years, the Napa has spilled its banks, flooding homes and businesses in the heart of California's scenic wine country. Millions were spent over the years trying to tame the river by dredging it, straightening it, hemming it in with levees and lining it with concrete. And when those efforts failed, millions more were spent repairing the damage and rebuilding flooded homes—again, in harm's way.

Finally, the people of Napa decided they'd had enough.

Rejecting proposals to pour yet more concrete, the town's voters instead chose to set the river free. They approved a plan to tear down some of the levees and rip out some of the concrete. Historic floodplain will be recreated so once again the river has room to meander. Some homes and families will be moved to higher ground. The people of Napa have decided to live *with* their river, instead of trying fruitlessly to rein it in.

"For over a century, we have fought a losing battle against the Napa River," town leaders wrote to voters. "We have failed because we didn't respect the river's natural tendencies." Now they do. And in the future, when the rains pour down and the river swells, Napa stands a better chance of staying dry.

This story of a town and its river is the story of America 30 years after the birth of the modern environmental movement. In redefining its relationship with nature, Napa exemplifies a new model of environmental decision making—one this Administration is working hard to promote. Napa's voters were not willing to choose between their economy and their environment—they wanted to preserve both. They made that decision as a community, working together. They had the courage to break with convention, and rediscover the wisdom of nature. And in so doing, they helped inspire new thinking in other communities, and within government agencies. The U.S. Army Corps of Engineers, the federal agency that will help Napa protect itself by letting the river run free, is now aggressively pursuing alternative approaches to flood control elsewhere around the country.

There is an important sidelight to this story that to me is particularly gratifying—the role played by the National Environmental Policy Act (NEPA). By requiring thorough analysis of the earlier, more traditional flood control proposals for the

Napa – and by providing the community another avenue for real input – NEPA helped bring about consensus on what turned out to be a better approach. By calling on us to think before acting, to explore all feasible alternatives, and to lay that information before the public, NEPA put the people of Napa in a position to do right by themselves, and by the environment.

NEPA is much more than a law requiring thorough, objective studies. It is the foundation of federal environmental policy making. And it is a visionary statement of the importance of integrating environmental protection into all that we do.

Indeed, long before we spoke of "holistic" approaches or "sustainable" development, the framers of NEPA were writing these concepts into federal law. NEPA directs federal agencies to conduct their programs in a way "calculated to foster and promote the general welfare, to create and maintain conditions under which man and nature exist in productive harmony, and fulfill the social, economic and other requirements of present and future generations of Americans." Environmental protection cannot be a goal unto itself, for it truly can be achieved only when fully integrated with our social and economic aspirations.

NEPA also happens to be the law that created the Council on Environmental Quality. When President Clinton appointed me chair of CEQ, I looked back to the original charge issued by Congress in 1970 to see how it might best be fulfilled in light of our present challenges. I found great wisdom in the words of the statute – in particular, its vision of "productive harmony." And I am proud of the many ways this Administration is working to make that vision a reality.

Today, our economy is the strongest in a generation, and our air and water are the cleanest in a generation. By accelerating the cleanup of "brownfields" and Superfund sites, we are protecting the health of our communities and our children while revitalizing neighborhoods and spurring economic growth. Through habitat conservation plans and other innovative approaches, we are protecting threatened and endangered species while assuring private property owners productive use of their land. By expanding right-to-know laws, we are offering communities information they can use to protect themselves from toxic risks while providing businesses with new incentives to cut costs through pollution prevention. In each of these cases, we are demonstrating that a strong economy and a healthy environment go hand in hand.

Our search for "productive harmony" has required that we craft a new approach. Early environmental efforts met with great success, but often generated unnecessary conflict and controversy. And increasingly, polarization produced deadlock, with both the economy and the environment suffering as a result. So we have worked hard to move beyond chronic conflict, forging collaborative strategies that meet common needs. And wherever possible, we are encouraging inno-

vative, common-sense solutions that achieve the greatest protection for our environment at the least possible cost.

These principles will continue to guide us as we meet the challenges ahead. Recently, for instance, the President launched a new Clean Water Action Plan to complete the job started 25 years ago by the Clean Water Act. Despite the Act's many accomplishments, 40 percent of our waterways remain too polluted for fishing and swimming. But rather than dictate solutions – and force communities and industries to pick up the tab, whatever it might be – we are setting strong standards and offering a helping hand. We are working in partnership with states, communities and farmers, and providing them with tools and incentives to clean our rivers, lakes and coastal waters. And we are encouraging a comprehensive "watershed" approach that looks at all the land contributing runoff to a river system – from forest to farm to urban neighborhood – and brings all the stakeholders to the table to identify priorities and the most cost-effective cleanup strategies.

These principles will guide us, too, as we confront perhaps the greatest environmental challenge we face – the challenge of global warming.

As we approach the 21st century, scientists tell us that the signs are clear. Our rising emissions of greenhouse gases have begun to affect the world's climate, and unless we take action to reduce them, our children and grandchildren will pay the price. The average global temperature is projected to rise 2 to 6 degrees over the next century, leading to increased flood and drought, rising sea levels, agricultural disruption, the spread of infectious disease and other health effects. The longer we wait to reduce our emissions, the more difficult the job, and the greater the risks.

Fortunately, there is international consensus that something must be done. An historic agreement negotiated in December, 1997, in Kyoto, Japan, lays the foundation for international efforts to head off global warming. Industrial nations committed to strong emissions reductions targets and, thanks to U.S. leadership, the agreement provides for flexible, market-based mechanisms for achieving them. Negotiations continue to flesh out many of the particulars, and to win commitments from developing countries to limit their emissions. But together, we have taken important first steps.

President Clinton recognizes that climate change is at once a challenge and an opportunity. The key to reducing greenhouse gas emissions is increased energy efficiency and wider use of clean energy technologies – which confer other economic and environmental benefits as well. And we are committed to achieving those reductions not through heavy-handed regulation, but through market-based approaches and strategic partnerships with the private sector. Through our Partnership for a New Generation of Vehicles, American automakers already have prototypes that get twice the mileage of today's cars and aim to have cars ready for mar-

ket by 2004 that are more efficient still. Our Energy Star program rewards companies that manufacture energy-efficient products — everything from computers to dishwashers to new homes — and consumers who buy them. And through the Partnership for Advancing Technology in Housing, we are working with the building industry to slash energy use in new homes 50 percent by 2008.

We stand at the threshold of a new millennium. Profound challenges await us, but we are prepared to meet them. We are more committed than ever to restoring and protecting our precious environment, and we have both the vision and the tools to do it. Sometimes it takes a far-reaching strategy that mobilizes all the nations of world against a common threat. Sometimes, though, it is as simple as one community coming together, discovering in its river the wisdom of nature, and having the good sense to honor it.

Kathleen A. McGinty
Chair

EXECUTIVE OFFICE OF THE PRESIDENT
COUNCIL ON ENVIRONMENTAL QUALITY
WASHINGTON D.C. 20503

LETTER OF TRANSMITTAL

The President

Sir: The Council on Environmental Quality herewith transmits its Environmental Quality Report for 1996 in accordance with section 201 of the National Environmental Policy Act of 1969 (42 U.S.C. 4341).

Sincerely,

Kathleen A. McGinty
Chair

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Part I

The National Environmental Policy Act

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2

NEPA and the Integration of Economic, Environmental, and Social Goals

In 1968, the heavily-polluted Cuyahoga River caught fire. This event, along with many others, led to a national debate and a demand to create an environmental policy. In the nearly 30 years since its enactment, the National Environmental Policy Act has been a foundation of our nation's environmental policy making. Senator Henry M. Jackson, one of the principal authors of the original law, remarked that NEPA "is a congressional declaration that we do not intend, as a government or a people, to initiate actions which endanger the continued existence or health of mankind: that we will not intentionally initiate actions which do irreparable damage to the air, land and water which support life on earth."

Congress did not simply issue a declaration, however. The framers of this statute understood that true environmental protection had to be incorporated into the very fabric of federal decision-making and integrated with our social and economic aspirations. The law requires federal agencies to conduct their programs in a way "calculated to foster and promote the general welfare, to create and maintain conditions under which man and nature exist in productive harmony, and fulfill the social, economic and other requirements of present and future generations of Americans."

While NEPA is often characterized as strictly an environmental protection statute, its goals are broader (See Box 1). It was designed to ensure that federal actions integrate economic, environmental and social goals so as to complement the goals of American communities.

The statute set forth four fundamental principles. The first is the integration of environmental, economic and social objectives—the explicit recognition that these goals are not contradictory or competing, but rather inextricably linked. The second is sound decision-making based on thorough, objective analysis of all relevant data. The third is effective coordination of all federal agencies in the development and execution of environ-

Box 1
NEPA's Policies and Goals

- Fulfill the responsibilities of each generation as trustee of the environment for succeeding generations.
- Assure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings.
- Attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences.
- Preserve important historic, cultural, and natural aspects of our national heritage, and maintain wherever possible, an environment that supports diversity, and variety of individual choice.
- Achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities.
- Enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

mental policy. And the fourth is openness in decision-making—giving communities and the public a direct voice in federal decisions affecting their communities and their well-being.

To advance these principles in the day-to-day workings of our government, NEPA established two primary mechanisms. The first is the Council on Environmental Quality. Congress recognized the need for a permanent environmental body within the Executive Office of the President, not only to advise agencies on the environmental decision-making process but to oversee and coordinate the development of federal environmental policy. This entails monitoring environmental trends, assessing the success of existing policies, advising the President on the need for more effective policies and, when necessary, mediating conflicts among federal agencies.

The second is implementation of an environmental review process. NEPA requires agencies to analyze the likely environmental impacts of any major action they propose to undertake. This may take the form of an environmental assessment and, when necessary, a more detailed environmental impact statement. In any given year, federal agencies and departments prepare approximately 500 draft, final and supplemental environmental impact statements and 50,000 environmental assessments. One of the critical roles assigned to CEQ by NEPA is overseeing agency implementation of the environmental decision-making process.

In a variety of ways, NEPA plays a vital role in integrating environmental, economic, and social goals. For example:

NEPA's authority can be used to develop new programs, such as the American Heritage Rivers Initiative, that seek to simultaneously foster environmental, economic, and social goals.

Though its mandate to examine proposed major federal actions, NEPA is an instrument that can look for alternatives that strike the best possible balance among economic, environmental, and social goals.

In many instances, NEPA can not only protect the environment, but save scarce financial resources as well.

The broad goals of the NEPA statute provide ample opportunities for federal agencies to use NEPA as a critical planning tool to integrate the concerns and values of communities.

NEPA is an important tool to advance our understanding of the environment, both through educational programs and research on complex subjects such as the cumulative effects of pollution and resource degradation.

Though its oversight mandate, CEQ has provided new impetus to revise regulations to streamline the process.

NEW INITIATIVES

Rivers run through America's landscape, its history and its future. American Indians developed river settlements and ceremonial centers. Adventurers explored new territories following the river and established fortresses to protect settlers. Water-powered sawmills, flour mills and textile mills in small villages and bustling cities peppered New England and the upper South. Tankers and freighters, steamboats and barges, canoes and kayaks, skipjacks and trawlers carried trading commodities from American community to American community. Slow moving waters, rapids and shallow pools, waterfalls and eddies, and marshes teemed with life that provided food and ecological services.

On the basis of NEPA and related statutes, the federal government continuously responds to threats to the nation's river heritage. In the State of the Union Address on February 4, 1997, President Clinton announced an initiative supporting community-led efforts relating to rivers that spur economic revitalization, protect natural resources and the environment, and preserve historic and cultural heritage. He has since issued Executive Order 13061 directing agencies to establish and implement the initiative.

The American Heritage Rivers initiative is voluntary and locally driven; communities choose to participate and can terminate their participation at any time.

To enhance federal assistance to community-based projects, the federal government solicited nominations from communities wishing to designate their rivers as American Heritage Rivers. The President will designate 10 American Heritage Rivers. The communities surrounding designated rivers will receive a number of benefits, including special recognition; focused support from existing federal programs; identification of a person (the "River Navigator") to serve as a liaison between the community and the federal government; and assistance from agencies throughout the federal government. The federal government will work to integrate and streamline its approach to providing existing federal services in designated American Heritage River communities in partnership with local leadership.

Additionally, the federal government will provide a new information center on the World Wide Web for community-based projects in economic revitalization, natural resources and the environment, and historic and cultural preservation. These Web pages will include information about services that can assist community projects and provide opportunities for dialogue between communities. The federal government will also provide this information to people without access to the Internet.

The President's Executive Order creates a new committee – the American Heritage Rivers Interagency Committee – that will be responsible for implementation of the initiative. The Committee will be composed of the following members or their designees at the Assistant Secretary level or equivalent: The Secretary of Defense, The Attorney General, The Secretary of the Interior, The Secretary of Agriculture, The Secretary of Commerce, The Secretary of Housing and Urban Development, The Secretary of Transportation, The Secretary of Energy, The Administrator of the Environmental Protection Agency, The Chair of the Advisory Council on Historic Preservation, The Chairperson of the National Endowment for the Arts, and The Chairperson of the National Endowment for the Humanities.

The Executive Order applies to all federal agencies and requires each of them to be responsive to the needs of river communities.

Each of these departments and agencies oversees programs and services, authorized by Congress, that can benefit citizens in riverfront communities. By engaging many of these departments and agencies in the creation of the American Heritage Rivers initiative, the Administration has tried to ensure that the initiative is founded on the various missions they are mandated to address – including economic revitalization, natural resources and environmental protection, and historic and cultural preservation – and is directed at improving the coordination and delivery of related services.

This initiative is set apart from other related federal programs. Its purpose is to further the goals of the National Environmental Policy Act (Section 101 (b) (4)), which requires the federal government to use all practicable means to preserve important historic, cultural, and natural aspects of our national heritage. The initiative does this by supporting local efforts to preserve and protect rivers, including their contributions to the culture, economy, and environment of the area.

In implementing the American Heritage Rivers initiative, federal departments and agencies have been directed by President Clinton to act with due regard for the protections of private property provided by the Fifth Amendment. The initiative will create no new regulatory requirements or rules for property owners or state, tribal, or local governments. It will use existing federal resources more effectively to assist communities.

SEEKING BETTER ALTERNATIVES

In its traditional role of evaluating the environmental impact of proposed major

federal actions, NEPA is an instrument that can look for alternatives that strike the best possible balance among economic, environmental, and social goals. The cases briefly described below illustrate the wide variety of instances in which NEPA plays an important role in looking for solutions that satisfy these multiple objectives. These examples are placed in the context of river protection, development and management.

Duck River, Tennessee

The Tennessee Valley Authority evaluated the environmental impacts of an existing dam, construction dike, and diversion channel on the Duck River in Tennessee. Cooperating agencies included Duck River Development Agency, the Army Corps of Engineers, and the Fish and Wildlife Service.

Originally, a new dam and reservoir were to be built as the downstream component of the Duck River project. The presence of several endangered species in the potentially affected part of the river prevented the construction of the dam and reservoir. Four alternatives were considered under the NEPA process, including maintaining the current uses, two different levels of making part of the land available for development, and turning the bulk of the land into a resource management area. The associated impacts of the alternatives included reduction in the amount of land available for recreational uses, decreased groundwater and surface water quality, and decreased tax revenues.

Greybull River, Wyoming

In the Bighorn Basin in north-central Wyoming, the Bureau of Land Management and the Corps of Engineers evaluated the potential impacts of a 150-foot-high earthen embankment dam and a 33,470-acre-foot impoundment in an unnamed drainage west of Roach Gulch and just south of Greybull River. The water from the project would be used to supplement existing irrigation supplies for use in irrigating crops and idle land. Two alternatives (essentially the same design at different sites) and the no-action alternative were considered. The potential impacts were loss of some grazing areas, loss of plant communities, blocked fish movement, some wetlands impacts, and increased demand for social services (housing, law enforcement, and medical). The preferred alternative would construct and operate the dam and reservoir to deliver irrigation water to the Greybull Valley Irrigation District.

Napa River, California

The Corps of Engineers evaluated a proposed project to provide flood protection by reconnecting the Napa River to its flood plain, creating wetlands throughout the area, maintaining fish and wildlife habitats, and retaining the natural characteristics of the river. The preferred alternative would include dike removal, channel modifications, levees and flood walls, bridge relocations, pump stations, and maintenance of roads and trails. The project would impact fish and wildlife habitat, cultural resources, aesthetics, recreation, transportation, air quality, and noise. Mitigation would reduce almost all of the impacts to insignificant levels. Initial losses in habitat

(riparian, marsh, wetlands) would be offset with additional creation of habitat. The preferred alternative was based on extensive collaboration between local community organizations and the Corps.

Guadalupe River, California

In San Jose, California, the Corps of Engineers evaluated the impacts of controlling flooding along the Guadalupe River. The project would increase the capacity of the river; channel modifications are proposed along eight sections totaling 6.4 miles of the river. Modifications are also proposed for adjacent portions of two tributaries, Ross and Canoas creeks.

Three alternatives were evaluated, including the preferred alternative, an alternative that would minimize vegetation impacts, and a no-action alternative. The Corps prepared a flood-control feasibility study and may fund the preferred project. The impacts of the proposal include soil instability, construction-related sedimentation, possible hazardous-waste exposure during construction, nuisance impacts to residents due to construction, removal of urban forests and vegetation, loss of wildlife habitat, reduction of shaded riverine aquatic habitat, and possible loss of archaeological resources. The preferred alternative would achieve flood protection through channel widening, modifications of levees, and the construction of bypass channels.

Rio Grande, New Mexico and Colorado

The Bureau of Land Management evaluated the environmental impacts of a plan for managing public land and allocating resources along 90 miles of the Rio Grande and some of its tributaries in New Mexico and Colorado.

The plan is unique because it recognized the interdependence of the people, land and natural resources along the northern portion of the Rio Grande in a single, cooperative, coordinated resource planning effort. The alternatives included the no-action alternative, a biodiversity protection alternative, a resource-use alternative, and the preferred alternative. The preferred alternative would provide for management that maintained and enhanced ecosystem health while optimizing recreational opportunities and other resource uses. The impacts of the preferred alternative included some adverse effects to riparian habitat from grazing; decline in water quality as a result of erosion, stream bank destruction, and bacteriological pollution and sedimentation, short-term restriction of grazing, and some localized negative effects to wildlife and fisheries habitat.

Madison and Missouri Rivers, Montana

The Federal Energy Regulatory Commission evaluated the environmental impacts of issuing a new license (relicense) for the Missouri-Madison Hydroelectric Project in Montana. The project consists of nine dams and their associated facilities on sections of the Madison and Missouri rivers in southwest Montana.

The alternatives included the no-action alternative, issuance of a new license, and a new license with alternative operating scenarios and/or environmental measures. The impacts that would occur include changes to land features, geology,

and soils; water quantity and quality; fisheries, vegetation, wildlife, cultural resources, aesthetic resources, recreation and land use; and socioeconomic resources. The alternative recommended by the Agency staff would develop the nine dams with additional measures to protect and enhance the affected environment.

Gauley River, West Virginia

The National Park Service evaluated the environmental impacts of managing the Gauley River National Recreation Area for outdoor recreational opportunities while protecting the natural area.

Four alternatives were considered, ranging from the no-action alternative to maximizing recreational opportunities. The impacts common to all of the alternatives included minor increases in air pollution, construction-related decreases in water quality, some soil compaction, and possible loss of wetlands. The preferred alternative would offer resource-based interpretive programs and would include a visitor information center, exhibits and some facilities.

Ocoee River, Tennessee

The Forest Service evaluated the environmental impacts of developing recreational opportunities within and adjacent to the Upper Ocoee River Corridor area of the Cherokee National Forest. The proposed development would include horse, mountain bike, and hiking trails, improved access to the river, and water access points for private paddling and commercial outfitting and guiding opportunities. Cooperating agencies included the Tennessee Valley Authority and the State of Tennessee.

Five alternatives were considered, ranging from the no-action alternative to maximum development of recreation opportunities (preferred alternative). The impacts associated with the project included increased traffic and use; increased soil erosion and sediment delivery, increased bacterial contamination, and some alteration of terrestrial habitat. The preferred alternative would maximize recreational opportunities by developing multiple use trails, constructing campgrounds, managing water flows, and providing additional access to the river.

Turkey Creek Watershed, Nebraska and Kansas

The Natural Resources Conservation Service evaluated the environmental impacts of a proposal to control flood waters in the Turkey Creek Watershed. The project would reduce sedimentation, enhance fish and wildlife habitat, enhance water quality, improve economic conditions, and provide recreational opportunities.

Six alternatives were considered with differing numbers of dams. Impacts involving the loss of wildlife habitat were associated with the preferred proposals. The preferred alternative would consist of 75 floodwater retarding dams in the watershed.

Las Vegas Wash, Nevada

The Bureau of Reclamation evaluated the environmental impacts of construction and operation of a wetlands park along a 7-mile reach of Las Vegas

Wash in Southeastern Nevada. In addition to creating outdoor recreational opportunities, the park would control erosion in the Las Vegas Valley. The impacts associated with the project include noise, generation of dust, and disruption of habitat due to construction, short-term destruction of wetlands, and disruption of some wildlife habitat. The preferred alternative would emphasize habitat enhancement, recreational facilities, and educational facilities.

PRUDENT SPENDING

In many cases, NEPA works not only to protect the environment, but to save scarce financial resources as well.

For example, when the U.S. Customs Service projected the need for a major expansion of the import lot and docking facility on the Rio Grande near the Juarez/Lincoln International Bridge between the U.S. and Mexico, the General Services Administration (GSA) undertook planning for the project and began preparation of an EIS examining six different ways to build the facilities. GSA also examined a "no-action" alternative, as required by CEQ regulations. The projected costs for building the facilities ranged from $27 million to $54 million. However, time and motion studies conducted for EIS purposes showed that backups at the existing facility resulted from too few inspectors rather than insufficient docks.

Computer modeling for the EIS indicated that, with new facilities already planned or under construction in the vicinity, there would be no need for the facility until sometime after 2020. As a result, the "no-action" alternative was selected and the money was saved.

Often, NEPA represents the best, if not only, opportunity for citizens to directly participate in federal decision making and direct an agency's attention to community concerns.

One such example is the Conway Bypass project in Myrtle Beach, South Carolina. In response to community concerns, the Federal Highway Administration created a wetland mitigation bank through innovative use of the NEPA mitigation process and, working with the South Carolina Department of Transportation, was able to preserve one of the East Coast's most significant ecological reserves. It is worth noting a second result — a $53 million savings in bridge costs. Additional savings are anticipated from the planned future use of the Sandy Island mitigation site in the Carolina Bays Parkway Project and the Mark Clark Expressway project.

This success was also made possible by the coordination, encouraged by NEPA, of several agencies, including the Highway Administration, the Army Corps of Engineers, the Environmental Protection Agency, the Fish and Wildlife Service, the National Marine Fisheries Service, and numerous state agencies.

Many agencies have learned NEPA's value as a planning tool to help define their activities and mission. The Department of Energy, for instance, has made extensive and effective use of programmatic and site-wide NEPA analysis in determining how best to transform its

nuclear weapons complex to appropriate post-Cold war functions and fulfill its environmental clean-up obligations. For example, a NEPA analysis of problems associated with hydrogen generated in underground radioactive waste storage tanks resulted in a modified proposal that saved about $435 million. As Secretary of Energy, Admiral James Watkins initiated a reinvigorated NEPA process at DOE and said it was key to the decision to defer selection of a costly tritium production technology.

"Thank God for NEPA," Admiral Watkins told the House Armed Services Committee in 1992, "because there were so many pressures to make a selection for a technology that might have been forced upon us and that would have been wrong for the country."

NEPA REINVENTION

Over the years, some federal managers have learned to "comply" with NEPA by preparing environmental impact statements that will pass muster with the courts. It is not the intent of NEPA, however, simply to generate paper that meets the letter of the law. Rather, NEPA seeks to encourage fully informed decision making with input from all interested parties. A growing number of agency managers understand the broader goals of the statute. Many agencies are reinventing themselves and have turned to NEPA as a critical planning tool to integrate the concerns and values of communities. If they are successful, NEPA will be a catalyst to alter the manner in which federal agencies operate in these communities.

CEQ recently undertook an assessment of NEPA's implementation, entitled *The National Environmental Policy Act: A Study of its Effectiveness After Twenty-five Years*. The study reflects the analysis and opinions of some of the people who know NEPA best and some who are affected by it most. The study also identified shortcomings in NEPA's implementation. Some participants said that implementation often focused on the narrow goal of producing legally sufficient environmental documents, that the process is lengthy and costly, and that agencies sometimes make decisions before hearing from affected citizens. Other participants noted that NEPA analysis is too technical and the documents are often long. Most thought that more NEPA training is needed at the senior official level as well as at the practitioner level.

Across federal agencies, the study found five factors critical to successful NEPA implementation:

- *Strategic planning*: the extent to which agencies integrate NEPA's goals into their internal planning process at an early stage.
- *Public information and input*: the extent to which an agency provides information to and takes into account the views of the surrounding community and other interested members of the public during its planning and decision-making process.
- *Interagency coordination*: how well and how early agencies share informa-

tion and integrate planning responsibilities with other agencies.

- *An interdisciplinary and place-based approach* to decision-making that focuses the knowledge and values from a variety of sources on a specific place.
- A *science-based* and flexible environmental management approach once projects are approved.

NEPA, like any statute, is not always implemented as effectively as it might be. CEQ's goal is to reinvent NEPA to reduce unnecessary delays, save taxpayer money and promote sensible, cost-effective reform of environmental decision making.

The Reinvention Project

Beyond case-by-case successes, there remains a need for a more systematic effort to enhance NEPA effectiveness throughout the federal government. CEQ calls this effort the NEPA Reinvention Project. It began with an analysis of NEPA implementation, followed by a series of pilot projects applying those findings to agency activities.

Following publication of the effectiveness study, CEQ officially launched its NEPA Reinvention Project. A small core staff was formed at CEQ to coordinate the project and to engage agency personnel in NEPA improvements and emphasize the original purpose of NEPA. The initial focus was planning and decision-making related to federal management of oil and gas resources, grazing, and timber uses on public lands. These topics present especially difficult applications of NEPA procedures and are often the subject of controversy and litigation.

IMPROVED UNDERSTANDING

Through its emphasis on assessing the nature of environmental impacts and predicting likely impacts in the event of a major federal action, NEPA provides a strong incentive for further research and education to advance our understanding of environmental impacts.

Education and Training

For the fifth consecutive year, CEQ and Duke University in 1997 taught "Implementing the National Environmental Policy Act on Federal Lands and Facilities." The course is designed for middle- and senior-level managers. It provides an overview of CEQ regulations and the requirements for public participation requirements, methods and tools for developing alternatives, requirements to address social and economic impacts, the requirements under Executive Order 12898 to address environmental justice, new guidance from the Administration with regard to transboundary impacts and global warming, new and emerging technologies to increase efficiencies in analyses, recent court cases interpreting NEPA and CEQ regulations, and new initiatives of the Administration.

Duke and CEQ are currently exploring the feasibility of adding a social and economic impact analysis, cumulative effects, current and emerging issues, and scoping courses.

Department of Justice Legal Education Institute. CEQ staff participated as

faculty in several training seminars run by the Department of Justice Legal Education Institute. The seminars focused on NEPA's purposes, procedural requirements and the relationship between compliance with NEPA and other laws and policies, such as the Endangered Species Act and Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations." Representatives of many federal agencies attended the sessions.

Exploring Complex Effects

In considering proposed actions affecting rivers, it is difficult to assess cumulative effects. These effects extend beyond a particular change, and include the impacts of minor but repeated actions. Some authorities contend that all environmental effects can be seen as cumulative, since almost all systems have already been stressed by humans. While it is difficult to predict and assess even direct effects with a high degree of certainty, learning to assess cumulative effects is essential to sustainable development goals. When sources of change are grouped so closely in time or space that the carrying capacity of a river is exceeded, the result is a diminished quality of life for the area's inhabitants and reduced potential for economic growth along the river. Analyzing for cumulative effects on the full range of resources, ecosystems, and human communities provides a mechanism for addressing sustainable development.

The Council on Environmental Quality recently published *Considering Cumulative Effects Under the National Environmental Policy Act*. While the handbook is not regulatory in nature, it presents practical methods for addressing coincident effects (adverse or beneficial) on specific resources, ecosystems, and human communities of all related activities, not just the proposed action.

The process of analyzing cumulative effects can be thought of as enhancing the traditional components of an environmental impact assessment: (1) scoping, (2) describing the affected environment, and (3) determining the environmental consequences. Generally, it is also critical to incorporate cumulative effects analysis into the development of alternatives for the less detailed environmental assessment, as well as the environmental impact statement. By reevaluating and modifying alternatives in light of projected cumulative effects, adverse consequences can be effectively avoided or minimized. Considering cumulative effects is also essential for developing appropriate mitigation measures and monitoring their effectiveness.

In many ways, scoping is the key to analyzing cumulative effects. It provides the best opportunity for identifying important issues to be addressed, setting the appropriate boundaries for analysis, and identifying past, present and future actions. Scoping allows the environmental analyst to "count what counts." By evaluating resource impact zones and the life cycle of effects rather than projects, the analyst can properly bound the study to capture the cumulative effects. Scoping can also facilitate the interagency cooperation needed to identify agency

Box 2
Principles of Cumulative Effects Analysis for Sustainable Development

- Cumulative effects are caused by the aggregate of past, present, and reasonably foreseeable future actions.
- Cumulative effects are the total effect, including both direct and indirect effects on a given resource, ecosystem, and human community of all actions taken, no matter who takes the action.
- Cumulative effects need to be analyzed in terms of the specific resource, ecosystem, and community being affected.
- It is not practical to analyze the cumulative effects of an action on the universe; the analyst must focus on the environmental effects that are truly meaningful for sustainable development.
- Cumulative effects on a given resource, ecosystem, and human community are rarely aligned with political and administrative boundaries.
- Cumulative effects may result from the accumulation of similar effects or the synergistic interaction of different effects.
- Cumulative effects may last for many years beyond the life of the action that caused the effect.
- Each affected resource, ecosystem, and human community must be analyzed in terms of its capacity to accommodate additional effects, based on its own time and space parameters.

and private sector plans within an ecosystem.

When the analyst describes the affected environment, he or she is setting the environmental baseline and thresholds of environmental change that are important for analyzing cumulative effects. Recently developed indicators of ecological integrity (e.g. index of biotic integrity for fish) and landscape condition (e.g. fragmentation of habitat patches) can be used as benchmarks of accumulated change over time. In addition, remote sensing and geographic information system (GIS) technologies provide improved means to analyze historical change in indicators of the condition of rivers, riverine ecosystems, and human communities, as well as relevant stress factors. Many dispersed local information sources and emerging regional data collection programs are now available to describe the cumulative effects of a proposed action.

Determining the cumulative environmental consequences of an action requires delineating the cause-and-effect relationships between multiple actions and the riverine ecosystems and human communities of concern. Analysts must extract from the complex networks of possible interactions those that substantially affect the river's resources. Then, they must describe the response of the river to this environmental change using modeling, trends analysis, and scenario build-

ing when uncertainties are great. The significance of cumulative effects depends on how they compare with the environmental baseline and relevant resource thresholds (such as regulatory standards or carrying capacity). Most often, the historical context surrounding the river is critical to developing these baselines and thresholds and to supporting both imminent and future decision-making (See Box 2).

Undoubtedly, the consequences of human activities will vary from those that were predicted; therefore monitoring the accuracy of predictions and the success of mitigation measures is critical. Adaptive management provides the opportunity to combine monitoring and implementation in a way that will ensure protection of the environment and the attainment of societal goals. It has the added benefit of advancing the practice of environmental impact analysis into a dynamic management tool, rather than an expensive time-consuming documentation exercise.

OVERSIGHT AND AGENCY IMPLEMENTATION

Federal agencies are required by CEQ regulations to adopt procedures based on the CEQ regulations, and tailored to the regulatory and program activities of the individual agency. Each agency is required to consult with CEQ while developing or revising their procedures and before publishing them for public comment. The NEPA Effectiveness Study has provided new impetus to revise regulations to streamline the process.

Agency NEPA Procedures

In 1996, CEQ reviewed and approved NEPA regulation revisions for the Air Force, Navy, Forest Service, Bureau of Land Management, Department of Energy, and the Food and Drug Administration. Each of the agencies took measures to integrate planning procedures and NEPA, to reduce unnecessary paperwork, and to ensure the public better opportunities to participate in decision-making.

Emergency Alternative Arrangements

CEQ regulations provide for alternative NEPA compliance arrangements in the event an agency needs to take an action with significant environmental effects before completion of an EIS. These provisions are used judiciously and rarely.

In August 1996, a fire in the Cascade Resource Area (managed by the Bureau of Land Management) and the Boise National Forest, both adjacent to the City of Boise, burned over 15,000 acres of federal, state and private lands. Hundreds of homes were threatened, and the fire destroyed brush and grassland on steep and fragile slopes surrounding Boise. The two land management agencies wanted to take immediate action to avert the threat of flooding, mudslides, and debris flows that could threaten human life and property, water quality, and soil productivity. An interagency group, composed of federal, state, and local agencies, recommended contour trenching and terracing not covered by previous NEPA analyses.

CEQ worked with the agencies to develop a process that included extensive prospective public involvement and com-

mitments for monitoring and mitigation, and allowed agencies to proceed with the action immediately. The work has been completed and damage to property and the environment was avoided.

In June 1996, an emergency developed involving extremely high fire risk on public lands in the San Ysidro Mountains in southern California, near the border with Mexico. The Bureau of Land Management (BLM) approached CEQ about alternative arrangements under NEPA for the construction of spur roads within the Otay Wilderness Study Area, along with construction of two helispots on nearby public lands. The high rates of fires in the area presented a severe risk to human life and to sensitive and endangered natural resources. The request was coordinated with the Border Agency Fire Council, a federal and state interagency group brought together to develop a coordinated strategy for the protection of life, property and natural resources in southern San Diego County. CEQ granted the request for alternative arrangements, which included a number of specific requirements for involvement from other federal agencies and consultation with interested non-federal parties.

Referrals

CEQ regulations establish procedures for referring to the CEQ "interagency disagreements concerning proposed major federal actions that might cause unsatisfactory environmental effects." Not later than 25 days after receipt of referral, the CEQ must respond in some manner, such as publishing findings and recommendations. This provision of the regulation is rarely used, but it has been credited with catalyzing resolution of disputes among agencies.

In March 1996, the Federal Energy Regulatory Commission (FERC) proposed two Orders to promote competition in wholesale electricity markets, including Order Number 888, which eliminated discriminatory pricing and opened access to transmission facilities and services. In April 1996, FERC published a final environmental impact statement for this proposed rule and published the rule in final form. On May 13, 1996, the Administrator of the Environmental Protection Agency referred Order Number 888 to CEQ primarily because of their concerns over future potential increases in air pollutants. As part of the formal referral process, CEQ conferred with agencies, states, industry, and nongovernmental organizations. In response to the referral, FERC and EPA made important commitments to future actions to protect clean air. On June 14, 1996, CEQ concluded that the referral process and subsequent agency responses had successfully resolved the disagreements between EPA and FERC.

CONCLUSION

In sum, NEPA's relative simplicity provides a dynamism that encourages rethinking as time and circumstances change. On a variety of fronts, that rethinking is taking place, though new initiatives, improved analysis, reinvigorated efforts to encourage public participation, and the continuing challenge of

finding creative solutions that foster both environmental protection, economic growth, and social welfare.

The nation's rivers are the quintessential combination of environmental, economic, and social values. Much of the nation's wealth and many of its major urban centers are located next to rivers. In the nation's long effort to protect water quality, rivers have played a central role.

Throughout the nation, people are engaged in crafting creative new solutions that protect rivers, foster economic growth, and enhance social welfare. These efforts, which are explored in depth in the next six chapters, embody the spirit that prompted NEPA's birth and the intellectual creativity that continue to mark its current application.

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18

Selected NEPA Cases in 1996

NEPA *and Critical Habitat under the Endangered Species Act*

In 1995, the Ninth Circuit Court of Appeals, in *Douglas County v. Babbitt*, 48 F.3d 1495 (9th Cir. 1995), held that NEPA does not apply to a decision to designate critical habitat for an endangered or threatened species under the Endangered Species Act (ESA). The court based its holding on the grounds that "(1) Congress intended that the ESA critical habitat procedures displace the NEPA requirements, (2) NEPA does not apply to actions that do not change the physical environment, and (3) to apply NEPA to the ESA would further the purposes of neither statute." 48 F. 3d at 1508.

Catron County v. U.S. Fish & Wildlife, 75 F.3d 1429 (10th Cir. 1996). Contrary to the Ninth Circuit, the Tenth Circuit Court of Appeals, in *Catron County*, concluded that the Secretary must comply with NEPA when designating critical habitat under the ESA. The court disagreed with the Ninth Circuit's earlier conclusion that the procedural requirements of the ESA, with regard to critical habitat designation, displaced the requirements of NEPA, finding instead that the ESA requirements for notice and environmental consideration only partially fulfilled the purposes of NEPA. 75 F.3d at 1437. Citing CEQ regulations, the court stressed that even though an action may be environmentally beneficial, the Secretary is not excused from NEPA's requirements. *Id.*

Those requirements, the court noted, "are not solely designed to inform the Secretary of the environmental consequences of his action. NEPA documentation notifies the public and relevant government officials of the proposed action and its environmental consequences and informs the public that the acting agency has considered those consequences ... To interpret NEPA as merely requiring an assessment of detrimental impacts upon the environment would significantly diminish the act's fundamental purpose - to 'help public officials make decisions that are based on understanding of environmental consequences, and take actions that protect, restore, and enhance the environment. 40 C.F.R. §1500.1(c).'" 75 F.3d at 1437. Therefore, in the court's opinion, meeting the ESA's core purpose by preventing the extinction of species through critical habitat protection, while arguably beneficial, does not completely satisfy the requirements of NEPA; potential detrimental impacts of designation must also be evaluated. *Id.*

From a factual perspective, the court focused on the county's allegations that the proposed designation would prevent continued government flood control efforts, significantly affecting nearby privately owned farms and ranches, as well as public roadways and bridges. *Id.* at 1437- 1438. "These claims," the court stated, "if proved, constitute a significant effect on the environment the impact of which and alternatives to which have not been adequately addressed by ESA." *Id.* at 1438.

Alternatives Analysis

CEQ regulations implementing the procedural provisions of NEPA describe the discussion of alternatives as the "heart" of the environmental impact statement. 40 C.F.R. §1502.14. Agencies are required to "rigorously explore and objectively evaluate all reasonable alternatives" and to "briefly discuss the reasons for their having been eliminated." 40 C.F.R. §1502.14(a). One such alternative that is required in every EIS is the so-called "no action" alternative, which considers the environmental consequences of not undertaking the action at all. When called upon to determine whether an agency has adequately considered alternatives to its proposed action, courts use a "rule of reason," focussing on whether the agency evaluated a reasonable range of potential alternatives. The "rule of reason" reflects the concerns addressed by the "arbitrary and capricious" standard of review, used by courts reviewing agency actions under the Administrative Procedure Act (5 U.S.C. sec. 706(2)(A)). This standard ensures that agency decisions are founded on reasoned evaluations of relevant factors.

Alternatives and the Need to Supplement

Dubois v. U.S. Dept. of Agriculture, 102 F.3d 1273 (1st Cir. 1996). The First Circuit Court of Appeals held that the U.S. Department of Agriculture Forest Service violated the "arbitrary and capricious" standard by failing to explore all reasonable alternatives in an EIS. The Forest Service had approved a special use permit that allowed the Loon Mountain Ski Area to withdraw water from Loon Pond for snowmaking purposes and to discharge water from another river into the pond. During the EIS process, commentors had suggested that the ski area could meet its snowmaking needs by building artificial water storage ponds. The "existence of a viable but unexamined alternative," the court stated, "renders an environmental impact statement inadequate." 102 F.3d at 1287, quoting *Idaho Conservation League v. Mumma*, 956 F.2d 1508 (9th Cir. 1992). The court found that instead of "rigorously exploring" this alternative, the Forest Service failed to address it at all in the final EIS 102 F.3d at 1288. As the court put it, "the final EIS contains no 'description' or 'discussion' whatsoever as to why an alternative source of water such as an artificially created storage pond would be impractical." *Id.* at 1289.

In addition, the plaintiffs argued that the preferred snowmaking/withdrawal alternative, described above, which

appeared for the first time in the final EIS, included "substantial changes" from any of the alternatives proposed in the prior drafts of the EIS. CEQ regulations require agencies to supplement draft or final EISs if the agency "makes substantial changes in the proposed action that are relevant to environmental concerns." 40 C.F.R. sec. 1502.9. The court agreed with the plaintiffs, saying "These are substantial changes from the previously-discussed alternatives, not mere modifications 'within the spectrum' of those prior alternatives. It would be one thing if the Forest Service had adopted a new alternative that was actually within the range of previously considered alternatives, e.g. simply reducing the scale of every relevant particular. It is quite another thing to adopt a proposal that is configured differently, in which case public commentors might have pointed out, if given the opportunity - and the Forest Service might have seriously considered - wholly new problems posed by the new configurations ..." 102 F.3d at 1292-1293. The court, therefore, concluded that the Forest Service's failure to prepare a supplemental EIS was arbitrary and capricious. *Id.* at 1293.

Alternatives, Viability, and Cumulative Impacts

Seattle Audubon Society v. Moseley, 80 F.3d [illegible] (9th Cir. 1996). In 1993, President Clinton established the Forest Ecosystem Management Assessment Team (FEMAT) to examine options and make recommendations regarding a forest management plan to cover federal lands in the Pacific Northwest. FEMAT examined ten alternatives in a single EIS prepared jointly by the Forest Service and the Bureau of Land Management. Alternative nine, the environmentally preferred alternative, provided for only an 80% likelihood that listed species would continue to be viable after the plan was implemented. In this case, the plaintiffs challenged the Forest Service and the BLM's choice of alternative nine on the ground that the agencies did not fully evaluate a reasonable range of alternatives before making their final decision because they failed to consider a "no action" alternative. The Ninth Circuit rejected this argument, noting that the agencies did consider a "no harvest" alternative that was eventually abandoned because it was deemed inconsistent with the need to find a balance between competing uses. 80 F.3d 1404. "Moreover," the court stated, "the federal defendant's consideration of alternative one, which would have protected all old growth timber ... provided a reasonable point of comparison for the other nine alternatives." *Id.*

The court also rejected the plaintiffs' arguments that alternative nine violated the National Forest Management Act's (NFMA) species viability standard and that it failed to address cumulative impacts of actions taken on non-federal land. First, regarding NFMA, the court held that because the federal defendants based their decision on current scientific knowledge, did not overlook any relevant factors, and made no clear errors of judgment, "their interpretation and application of the NFMA's viability regulations

was reasonable." *Id.* Second, the court also upheld the adequacy of the cumulative effects analysis in the EIS, which assumed that non-federal land would be managed to avoid harm to threatened species. In reaching this conclusion, the court relied on the Supreme Court's affirmation, in *Babbitt v. Sweet Home Chapter of Communities for a Great Oregon*, 515 US 687 (1995) that the Endangered Species Act protects listed species from harm caused by habitat modification or destruction on federal and non-federal land. *Id.* at 1405.

Standing

Committee to Save the Rio Hondo v. Lucero, 120 F.3d 45 (10th Cir. 1996). Taos Ski Valley proposed to amend its special use permit, issued by the Forest Service, to allow for operation of its facilities during the summer. The Forest Service prepared an environmental assessment and a finding of no significant impact for the proposal. Plaintiffs, landowners and users downstream from the ski area, brought suit alleging that the Forest Service had violated NEPA because it failed to do an EIS on the proposal. At the outset, the court recognized that the plaintiffs, in seeking to protect their recreational, aesthetic, and consumptive interests in the land and water affected by the proposal, fell within the zone of interest that NEPA was designed to protect. 102 F.3d at 448.

Next, the court determined whether the plaintiffs met the other basic standing requirements. First, as to injury in fact, the court relied on a two-part test. Under this test, the plaintiff must show that: 1) in making its decision without following NEPA, the agency created an increased risk of environmental harm, and that 2) this increased risk injured the plaintiff's concrete interests. *Id.* at 448. To satisfy the second part of this test, the plaintiff must demonstrate either its geographical nexus to, or actual use of, the site of the agency action. *Id.* The court found that the plaintiffs' averments that the Forest Service's uninformed decision to allow summertime use of the ski area would result in increased water consumption, increased sewage discharge, increased mechanization and development, and overall disturbance of the recreational and aesthetic value of the land in and around the ski area were sufficient to establish that plaintiffs suffered an increased risk of environmental harm. *Id.* at 450. Further, because the plaintiffs actually used the land and water that the Forest Service's uninformed decision had exposed to an increased risk of environmental harm, the plaintiffs had established an injury in fact. *Id.* at 451. Once the court had drawn this conclusion, it had little difficulty finding that the plaintiffs' injury was directly traceable to the Forest Service's failure to comply with NEPA, and that the plaintiffs' injury would be redressed by a court decision requiring the Forest Service to comply with NEPA. *Id.* at 452.

City of Los Angeles v. Department of Agriculture, 950 F. Supp. 1005 (C.D. Cal. 1996). In this case, the Forest Service prepared an EIS for an oil pipeline project that was to cross the Angeles National Forest. In its final EIS, the For-

est Service chose a proposal by Pacific Pipeline Systems, Inc. (PPSI) as the environmentally preferred alternative for the project. Southern California Edison Company (Edison), one of PPSI's competitor's, challenged the EIS, alleging that the Forest Service violated NEPA. Specifically, Edison asserted that construction of the PPSI proposal would cause substantial environmental injury to Edison. To determine whether Edison was within the "zone of interest" of NEPA, the court employed a three-part test, requiring Edison to: 1) allege a non-pretextual environmental injury, 2) show that its claim is more than marginally related to, and not inconsistent with, the purposes of NEPA, and 3) be a reliable private attorney general to litigate the issues of the public interest. 950 F. Supp. at 1012. The court concluded that although Edison's environmental injuries were not a mere pretext, Edison's injuries were primarily economic. *Id.* at 1013. "To allow a direct competitor," the court stated, "under the banner of environmental champion, to raise an interminable series of legal challenges... would be 'so marginally related to [and] inconsistent with the purposes implicit in [NEPA]' that it cannot reasonably be assumed that Congress intended to permit Edison's suit." *Id.*, quoting *Clarke v. Securities Industry Assn.*, 479 U.S. 388 (1987). In addition, the court found that Edison's strong economic interest in the litigation would prohibit it from protecting the public interest. *Id.* Consequently, the court held that Edison was not within the "zone of interest" of NEPA and, therefore, did not have standing. *Id.* at 1015.

Timber Salvage Rider

In 1995, Congress passed the Supplemental Appropriations for Disaster Assistance and Rescissions Act (Rescissions Act). Pub.L. No. 104-19, 109 Stat. 194, effective July 27, 1995. Although the Act was primarily an appropriations bill, it contained a rider which, among other things, included provisions for an emergency program to award certain "salvage" timber sales in areas of the nation's forests that had suffered damage due to past fire, drought, and disease. To expedite these salvage timber sales, the Forest Service was deemed exempt from compliance with the requirements of all major environmental laws, including NEPA. Section 2001(k) Pub.L. No. 104-19, 109 Stat. 194. As a substitute, the rider replaced NEPA's procedural requirements with a combined environmental assessment and biological report. Section 2001(c)(1)(A) Pub.L. No. 104-19, 109 Stat. 194. The following cases illustrate the federal court treatment of challenges to salvage sales under the Rescissions Act. The rider expired on December 13, 1996.

Sierra Club v. Forest Service, 93 F.3d 610 (9th Cir. 1996). In this case, the Sierra Club had challenged a salvage timber sale under NEPA, but while the action was pending, Congress passed the Rescissions Act. The sale had already been advertised and offered on the date that the Rescissions Act was passed. The Ninth Circuit held that because the Rescission's Act waived the requirements of NEPA, Section 2001(k) of the Act mandated the release of such sales irrespective of any NEPA violations. 93 F.3d

614. Therefore, because NEPA could not provide any relief, the Sierra Club's challenge was rendered moot. *Id.*

Ozark Chapter/Sierra Club v. Thomas, 924 F. Supp. 103 (E.D. Mo. 1996). The Sierra Club argued that the documentation required by the Rescissions Act salvage timber rider was composed of two separate components: 1) an environmental assessment (EA) under NEPA, and 2) a biological evaluation under the ESA. In this case, the Forest Service decided that the sale fell under a categorical exclusion. The court rejected this argument, concluding that the Act called for a single document providing environmental analysis at the sole discretion of the concerned Secretary and thus the Secretary also had the sole discretion to determine the scope of the evaluation. 924 F. Supp. at 106. Therefore, in the court's opinion, the Secretary of Agriculture's decision to apply a categorical exclusion instead of an EA was appropriate for the sale in question. *Id.*

Cumulative Effects Analysis

CEQ regulations require agencies to consider cumulative impacts, defined as those which result from "the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions." 40 C.F.R. sec. 1508.7. Cumulative impacts can result from actions which are individually minor, but collectively significant. *Id.* When preparing environmental analyses under NEPA, agencies must consider cumulative impacts of actions regardless of what agency or person is responsible for the action. *Id.* When determining whether agencies have adequately addressed cumulative impacts, courts look to the interdependence and interrelatedness of the actions in question.

Inland Empire Public Lands Council v. U.S. Forest Service, 88 F.3d 754 (9th Cir. 1996). The plaintiffs challenged a Forest Service EIS on certain timber sales, arguing that the Forest Service erred by confining its population viability analysis (required by regulations implementing the National Forest Management Act) to the area immediately surrounding the sale, rather than including in the analysis lands "adjacent to" the sale area. The Ninth Circuit rejected the plaintiffs' characterization of the effects on species on these "adjacent" lands as cumulative impacts. The court noted that while cumulative impacts challenges focus on effects of other past, present, and future actions, the plaintiffs in this case were merely challenging the geographic scope of the proposed action. 88 F.3d at 764. Furthermore, the court held that requiring the Forest Service to analyze separately each species to determine the area covered by its particular ecosystem and then analyze its population viability in that area would be impractical. *Id.* The court concluded that the Forest Service was not arbitrary and capricious in ignoring effects on populations of sensitive species living outside the sale area boundaries. *Id.*

Airport Neighborhood Alliance, Inc. v. U.S., 90 F.3d 426 (10th Cir. 1996). Albuquerque International Airport proposed to expand one of its runways. In response, the Federal Aviation Administration

(FAA) prepared an EA on the proposal and issued a finding of no significant impact (FONSI). Plaintiffs challenged the FAA's FONSI on the ground that the EA did not adequately address potential cumulative impacts of the runway expansion. Specifically, plaintiffs argued that because the runway expansion was one of several projects proposed by the airport's Master Plan, the FAA should have addressed the runway expansion in the context of the larger contemplated expansion by the airport. The Tenth Circuit Court of Appeals found no "inextricable nexus" between the runway expansion and the other projects proposed in the Master Plan. *Id.* at 431. In the court's opinion, the expanded runway would have functionality irrespective of the other projects in the Master Plan. *Id.* Therefore, the court concluded, it would be neither unwise nor irrational for the airport to complete the runway expansion, even if it never went ahead with any of the other projects in the Master Plan. *Id.*

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Part II

Along the American River

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Along the American River

America's rivers are an integral part of the nation's heritage and wealth. They are simultaneously sources of water for drinking, irrigation, and industry; conduits to move people and products; nurturers of both aquatic and terrestrial biodiversity; and treasure troves of scenic, historic, and recreational pleasure.

From the nation's birth through about the 1950s, the story of the American river is largely about taming its force. Public and private efforts were aimed at reducing the risks of floods, providing assured supplies of water for cities and industry, and bringing water to the vast, largely arid West.

In the 1930s and 1940s, many of the nation's rivers were little more than handy receptacles for municipal waste and industrial toxins. They had become putrid stews carrying waterborne disease, threatening human health, and destroying plant and animal resources. Partly in response to the damage done to the nation's waters in the first half of the 20th Century, the national focus began to shift to water quality in the 1950s. Over the next four decades, a massive investment was made to reduce point-source pollution and improve the quality of the nation's rivers.

In the 1990s, truly remarkable and exciting changes are taking place in the nation's collective thinking about rivers.

- People and institutions increasingly think about rivers in holistic terms, either in the context of watersheds or as interconnected systems that may span hundreds and even thousands of miles from headwaters streams to river's end in estuaries and oceans. The old adage that "we all live downstream" has never been more relevant.
- Massive floods in recent years have underscored the complexity of river systems and the need for comprehensive planning. Responding to problems such as catastrophic flooding reveals the complexity of environmental problems: there are many sources of stress, and many, varied solutions.
- Escalating costs of highly engineered structures and the federal balanced budget imperative have created new opportunities for locally led initiatives. Instead of driving top-down solutions, federal agencies now promote collaborative planning with early inclusion of all interested parties at the local and state level. Broader involvement of all interested groups

often leads to more creative, more informed, and more cost-effective solutions. Groups that traditionally didn't communicate are now finding common interests.

The extent of watershed-level activity is remarkable. From Rivers Unlimited in Ohio and Idaho Rivers United to the Alabama Rivers Alliance and Amigos Bravos in New Mexico, citizen groups across the country are adopting watersheds as their organizing principle. Some 3,000 river and watershed organizations are listed in the *1996-97 River and Watershed Conservation Directory*. Watershed '96, a conference sponsored by the U.S. Environmental Protection Agency and others, drew 2,000 participants in the spring of 1996.

National groups such as River Network, Know Your Watershed, Pacific Rivers Council, American Rivers, Trout Unlimited, the Appalachian Mountain Club, Restore America's Rivers and others are playing diverse roles as advocates, communicators, and teachers.

States have moved forcefully. Florida, Wisconsin, Massachusetts, New York, Texas, and Maryland have passed legislation or established specific programs to deal with clean water and other issues at the watershed level.

North Carolina's "whole basin approach" to water quality protection focuses on coordinating and integrating all program activities for each of the state's 17 major river basins.

Resources are mobilized to assess all waters in a basin and develop a management plan that targets priority problems and pollutant sources. These plans provide a basis for management decisions such as National Pollutant Discharge Elimination System (NPDES) permit renewals, enforcement, and monitoring.

At the national level, numerous efforts are underway to look more broadly at environmental problems. After the tragic 1993 floods in the Midwest, the administration created a Floodplain Management Task Force that produced a multivolume report, paving the way for numerous subsequent changes in the federal approach to floodplain management. An Interagency Ecosystem Management Task Force also produced a massive review of the opportunities and impediments to implementing an ecosystem approach to environmental management.

Federal agencies now recognize the need to work together as well as with state and local governments and the private sector. For example, Coastal America — a partnership of 11 federal agencies and the White House Council on Environmental Quality — helps build partnerships among federal agencies, the states, and nongovernmental organizations.

This edition of *Environmental Quality* uses "The American River" as an extended metaphor to describe environmental problems and opportunities along the course of a river. While the focus is on rivers as an organizing tool, a broad range of other environmental issues will be considered.

A few cautionary notes are in order.

- In chapters 3-6, the discussion is organized in terms of the distinctive segments of a river, beginning with headwaters and ending with estuaries.

and coasts. The placement of subjects in these chapters is only illustrative; it is not meant to imply that such activities occur only in these segments of a river.

- The lines between "urban" and "rural" are increasingly blurred; most watersheds today are characterized by a mix of land uses, some predominantly "urban" and some predominantly "rural."

Though much of the discussion considers the impacts of human activities on water quantity and quality, the real point of this report is to think broadly about the complexity of environmental problems, about the many groups that have an interest in environmental problems, and about challenges posed by indirect and cumulative effects that are not easily understood.

Watersheds and their component parts —upland drainage areas, rivers, streams, lakes, and estuaries— are a useful focal point because they integrate nearly all aspects of the environment. In assessing any particular development, governments must consider a broad array of potential effects on a stream, including impacts on water quality and quantity, riparian forests, wetlands, wildlife corridors, and aquatic habitat, to name just a few. Environmental managers also recognize that watersheds are often the units that actually define a problem, and are more relevant than state or national boundaries when considering natural resources management.

The well-known phase, "Think Globally, Act Locally," has a great deal of merit. This report is a reminder that acting locally is a vital part of our efforts to protect the environment, and that much new thinking and acting is occurring at the local, state, and regional level. As we learn more about environmental problems, it is also a reminder that the gap between local, regional, national, and global thinking and action is not as wide as we may think.

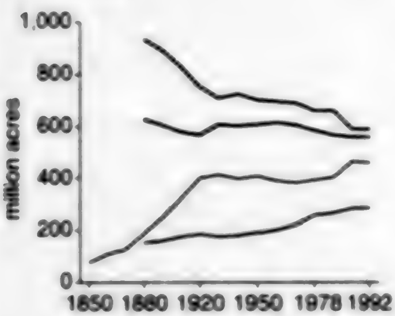
FROM DEVELOPMENT TO STEWARDSHIP

The state of America's rivers reflects our national and political history, not to mention the many thousands of years of natural history that preceded the arrival of the first settlers from Europe.

As settlers moved from east to west across the United States in the 18th and 19th centuries, rivers were the principal routes of movement, and riverbanks were the first places to be settled.

Steamboats, needing wood for fuel, were responsible for much of the early loss of riparian forests. Soon thereafter, early settlers began clearing forests for agriculture (Figure 1.1). This historic land-use pattern permanently changed the environment in much of the Midwest, but proved more transitory in other regions of the country. In the Northeast, for example, extensive clearing was common until the mid-1800s, when farming became unprofitable and farms were increasingly abandoned. In Petersham Township in central Massachusetts, nearly 85 percent of the land was cleared by 1850; today, forests have returned to

Figure 1.1 Major Uses of Land in the Contiguous United States, 1850-1992



Source: Daugherty, A.B., *Major Uses of Land in the United States, 1992* (USDA, ERS, Washington, DC, 1995) and earlier reports.

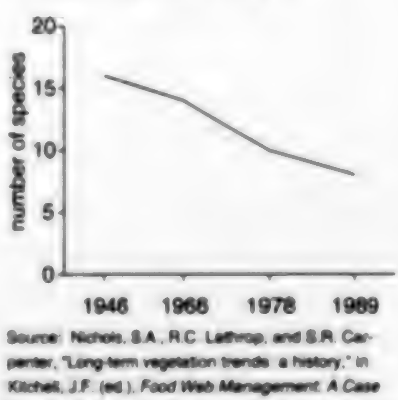
about 90 percent of the township, and most of the cleared land is devoted to residential development.

The historic pattern of clearing forest land along rivers has remained a relatively common feature of the American landscape until recently. Prior to settlement, woody riparian vegetation covered an estimated 30-40 million hectares in the contiguous United States; by the early 1970s, at least two thirds of that area had been converted to non-forest land uses and only 10-14 million hectares remained wooded. In much of the arid West, the Midwest, and the Lower Mississippi River valley, riparian forests have been reduced by more than 80 percent.

Along the Willamette River in Oregon, for example, the streamside forest in 1850 extended up to 3 kilometers on both sides of a river characterized by multiple channels, sloughs, and backwaters. By 1967, government-sponsored programs for forest clearing, snag removal, and channelization had reduced the Willamette to a single uniform channel that had lost more than 80 percent of its forest and land-water edge habitats. Agriculture, logging, and urbanization all had important environmental impacts, increasing runoff of silt, nutrients, and pollutants into rivers and lakes. Increased silt and nutrients, in turn, began a process of euthrophication that killed many desirable plants and encouraged the growth of nuisance plants and algae. The loss of native plants and chemical changes in the water subsequently led to a loss of animal species, including fish and waterfowl.

In the region around Lake Mendota, Wisconsin, the conversion to agriculture was largely complete by the 1870s. By the 1880s, large blooms of blue-green algae

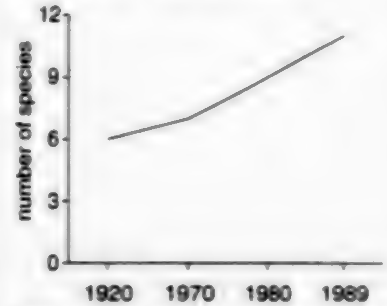
Figure 1.2 Aquatic Plants in University Bay, Lake Mendota, Wisconsin, 1946-1989



Source: Nichols, S.A., R.C. Lathrop, and S.R. Carpenter, "Long-term vegetation trends: a history," in Kitchell, J.F. (ed.), *Food Web Management: A Case Study of Lake Mendota, Wisconsin* (Springer-Verlag, New York, 1992).

were common. By 1989, roughly a century later, about half the lake's species of aquatic plants were gone (Figure 1.2). The beds of wild celery that once supported canvasback ducks and other migratory waterfowl and the native pondweeds that were vital nursery and rearing habitat for many fishes had also disappeared. These beneficial plants were largely replaced by coontail and an exotic, Eurasian watermilfoil, both of which have low food value for fish and wildlife. Deep-water insect populations began to decline around 1950. Native fish populations have declined by about one third (Figure 1.3); the causes include overfishing, habitat loss, the disappearance of native aquatic plants, and the stocking of the lake with predatory fish for game purposes.

Figure 1.3 Cumulative Loss of Native Fish from Lake Mendota, Wisconsin, 1920-1989



Source: Magnuson, J.J. and R.C. Lathrop, "Historical changes in the fish community," in Kitchell, J.F. (ed.), *Food Web Management: A Case Study of Lake Mendota, Wisconsin* (Springer-Verlag, New York, 1992).

The loss of native plants and animals has been especially severe in our lakes, rivers, and other waters. By 1989, in spite of conservation and restoration efforts, over 100 species of freshwater fishes were added to the threatened or endangered list and more than 250 were in danger of disappearing.

The Changing Federal Role

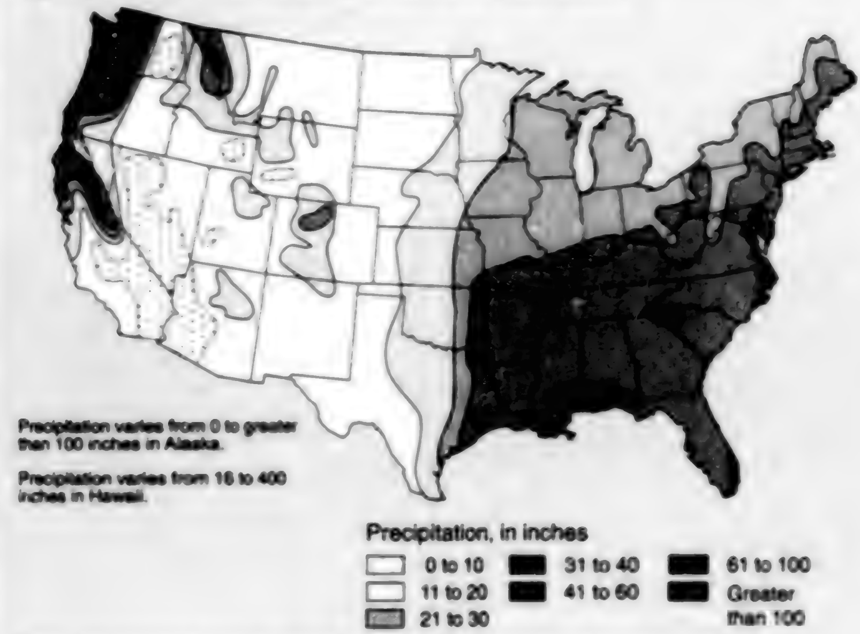
The early history of water resources development in the United States has two focal points: the effort to reduce the risks to human life and settlements posed by floods, through the construction of dams, levees, and other measures; and the effort to take greater advantage of the economic benefits of water, by providing an assured supply of water for irrigation, industry, and public consumption.

In both cases, the nub of the problem was the unpredictability of precipitation and water supply in much of the nation, and particularly in the states west of the 100th Meridian. The area east of the Mississippi River typically receives more than twice as much annual rainfall as the area west of the Rocky Mountains (Figure 1.4) (Box 1.1).

The federal authority to regulate water stems from an 1824 Supreme Court case, *Gibbons vs. Ogden*, in which the court confirmed the federal government's power to protect and promote navigation under the commerce clause. The navigation authority became the constitutional foundation for federal regulation of water use.

Congress and the Supreme Court historically interpreted the commerce clause quite broadly, citing it as the federal authority to develop water resources for irrigation, hydropower, flood control, and municipal and industrial water use, as well as to prevent environmental degrada-

Figure 1.4 Mean Annual Precipitation in the United States



Source: Adapted from National Climatic Data Center, *Climatography of the United States No. 81.*

tion or restore past environmental damage.

After the turn of the century, the federal government assumed a much larger role in water resources development. The Reclamation Act of 1902 gave the federal government a major role in the development of a vast infrastructure of dams, canals, and other structures to support irrigated agriculture in the West, generate power, and provide water for municipal and industrial usage. The New Deal transformed the Bureau of Reclamation's program into a regional water development program, building large storage reservoirs to support irrigated agriculture and urban growth. Hoover Dam, which was built to augment supplies for California's Imperial Valley and for Los Angeles' growing needs, became the model for more large multiple-purpose projects that began during the Depression and continued in the 1960s. In all, the Bureau of Reclamation constructed some 133 water projects in the West.

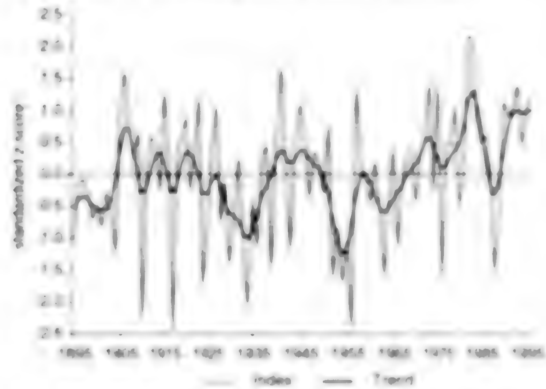
At about the same time, the Army Corps of Engineers began to expand its flood control mission. The Corps builds, operates, and maintains navigation channels, reservoirs and levees for flood control and incidental uses such as hydroelectric power generation. The Corps' navigation authority also became a limited form of river basin management, as flood control and navigation objectives required the Corps to plan and manage

Box 1.1
Trends in Precipitation

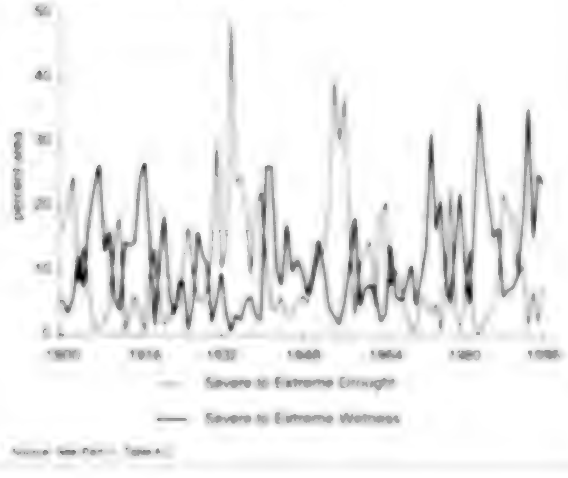
In an average year, about 9 percent of the contiguous United States is unusually dry and about 9 percent is unusually wet. But there is considerable variation in these numbers. In 1983, 36 percent of the country experienced unusually wet weather. In the Dust Bowl year of 1934, almost half the country—48.8 percent—was extremely dry. (See Part III, Table 6.2)

For the nation as a whole, precipitation trends have been generally above normal during the 1970-96 period, especially since 1992 (Box Figure 1.1). In both 1995 and 1996, roughly one fourth of the country experienced unusually wet weather (Box Figure 1.2). In addition, much of the country has been struck by natural disasters in the past few years. During July and August 1993, devastating floods hit the lower Missouri River, the upper Mississippi River, the Illinois River, and many of their tributaries. Thirty-eight lives were lost, and estimated damages were between $10 billion and $16 billion.

Box Figure 1.1 U.S. Precipitation Trends, 1895-1996



Box Figure 1.2 Severe to Extreme Wetness and Drought in the Contiguous United States, 1900-1996



on a basinwide scale. The Department of Agriculture also had a dam-building role through its Soil Conservation Service (now the Natural Resources Conservation Service), which financed small dams on the upper reaches of watersheds.

The reclamation program was originally envisioned as a way to support the development of small farms in the West. That program limited water deliveries to 160-acre tracts (320 acres when both a husband and wife held title), with project costs to be repaid in 10 years by the beneficiaries. But most projects could not meet the repayment obligation, so repayment periods were progressively extended and the costs of project water and power were subsidized in various ways. The subsidies included interest-free repayment charges and the use of an "ability-to-pay" standard for cost recovery, which allowed Reclamation to shift some of the repayment obligations from irrigators to hydroelectric power generation. The acreage limitation policy and subsidies have long been criticized as economically inefficient and environmentally unsound.

The generation of hydropower also emerged as a major part of the federal role in water development. Several controversies over hydropower developed over the course of many decades. One key issue concerned whether the federal government or private utilities would capture the benefits of prime dam sites. The Federal Power Act of 1920 allowed private access to hydroelectric sites subject to a federal license. Since then, power generation has evolved into a mixed system of privately and publicly generated power.

Rivers and coastal waters are also important for waterborne commerce. The water transportation system includes harbors, ports, channels, wharves, locks and dams. Some commercial water facilities are constructed and maintained under federal programs, while others are local or private. For example, the Coast Guard operates the "aids-to-navigation" system, enforces safety and pollution prevention regulations for the design and operation of vessels and marine facilities along coastal waters, and, with EPA, coordinates response to oil and hazardous materials spills.

Other federal agencies also have an important role in water issues. The Fish and Wildlife Service (FWS) and the National Marine Fisheries Service administer the Endangered Species Act and the Fish and Wildlife Coordination Act, to protect species threatened by a federal activity or where private actions may harm species when water is removed from stream channels.

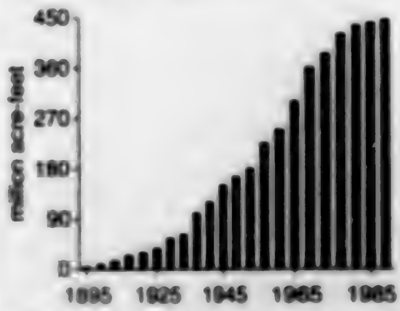
The era of building large dams for traditional needs such as flood control, water supply, and irrigation is now essentially complete, though the nation will continue to develop its water resources for recreation, some additional water supply, environmental enhancement, navigation, and probably some low-head hydro. The nation has about 75,000 dams, including some 2,600 large dams that each store more than 6 million cubic meters of water. Water storage in reservoirs increased to 445 million acre-feet (Figure 1.5).

The Emerging Federal Conservation Role

The rise of the conservation movement and of federal conservation programs has had an important impact on water resources development.

In the first half of the century, fish and wildlife impacts were generally a minor issue in the construction of federal reclamation projects. Early responses included authorizing agencies to construct fish ladders and hatcheries, create wildlife refuges, and operate reservoirs in a manner consistent with fish and wildlife protection. Until 1958, fish and wildlife protection was generally a permissible but minor use of water. The 1958 Fish and Wildlife Coordination Act mandated that fish and wildlife receive "equal consideration" with other project purposes, and the National Environmental Policy Act of 1969 (NEPA) became a major new vehicle for the evaluation of fish and wildlife impacts in pending federal projects. The Endangered Species Act of 1973 required federal agencies or licensees to take all necessary steps to preserve endangered species.

Figure 1.5 Reservoir Storage in the United States, 1895-1990



Source: Ruddy, B.C. and K.J. Hitt, *Summary of Selected Characteristics of Large Reservoirs in the United States and Puerto Rico* (USGS, Reston, VA, 1988) with updates by W.B. Solley, USGS, 1997.

The original focus of the Wild and Scenic Rivers Act of 1968 was to preserve prime undammed rivers. Since then, the program has broadened its focus to river and corridor protection generally. About 10,000 river miles are protected by the Wild and Scenic Rivers Act.

Watershed protection also has been a focus of federal activities since the late 19th Century. The 1897 Organic Administration Act, which provided management authority and direction for the forest reserves, expressed the congressional intent that forest reserves be managed for both timber production and watershed protection. The Multiple-Use, Sustained-Yield Act of 1960 included watersheds as one of the specific multiple uses, along with outdoor recreation, range, timber, and fish and wildlife. The National Forest Management Act of 1976 directed that guidelines for the creation of forest plans consider watershed protection, and that no harvesting should take place in areas where irreversible watershed damage could occur. Forest Service regulations require planners to evaluate hazardous watershed conditions, provide instructions to avoid or mitigate damage at specific sites, and give special attention to 100-foot wide riparian zones along perennial streams, lakes, and other water bodies.

The Bureau of Land Management (BLM) operates under generally similar mandates. The Federal Land Policy and Management Act of 1976 included

resources dependent on watershed protection as part of BLM's multiple-use mandate. The Public Rangelands Improvement Act of 1978 recognized the serious deterioration of public rangelands and directed BLM to take rehabilitative measures to restore viable ecological systems. BLM is paying increasing attention to the protection of riparian areas and stream ecosystems. The agency has the authority to exlude livestock from sensitive riparian areas, but is not required to do so.

The National Park Service (NPS) has a strong watershed protection mandate, but has limited authority to deal with impacts to park resources that arise outside of park boundaries.

By the 1950s, the importance of managing land uses to achieve water supply and quality goals was understood. While plans were being approved for major flood control works, agricultural forces argued for a program of flood control upstream in small watersheds. The concept combined structures for flood control with the idea of reducing erosion, runoff, flooding, and sedimentation.

The Watershed Protection and Flood Control Act of 1954 established a mechanism for the Soil Conservation Service (now the Natural Resources Conservation Service) to work on small watersheds of no more than 250,000 acres. The goals of the Small Watershed Program include flood prevention, watershed protection and water management. Projects include a combination of land treatment, structural, and nonstructural measures to enhance natural resource management and improve economic and social conditions in watersheds. Local groups, organized into legally recognized bodies, are central to the development and success of these projects. Groups provide land, easements, rights of way, and operations and maintenance inputs. With strong local involvement, projects reflect community priorities and serve to bring together disparate interests to solve mutually identified problems.

Today, the concept of watershed protection to address water supply issues has returned to the fore of water resource management approaches. The primarily structural approaches characterizing the earlier part of this century are giving way to more holistic approaches, incorporating nonstructural approaches and other conservation practices that enhance watershed function. The approach is based on a simple premise – that managing precipitation where it falls is the most effective and efficient solution to taming the river.

A comprehensive flood management strategy could include nonstructural approaches such as maintaining or restoring wetlands to hold precipitation, returning parts of watersheds to native vegetation, and increasing the moisture-holding capacity of soils. Healthy wetlands are particularly efficient at cycling moisture and contribute to a favorable distribution of water – absorbing water when it is plentiful and releasing it gradually.

The many efforts underway to manage water more efficiently also are paying off in terms of recent reductions in total national water withdrawals (Box 1.2).

Box 1.2
Trends in Water Withdrawals

During the period from 1950 to 1980, water use rose faster than the rate of population growth, increasing from about 184 billion gallons per day in 1950 to 445 billion gallons daily by 1980 (Box Figure 1.3). Over half of the 1980 total was used for industrial purposes—primarily thermoelectric power—and another third was used for irrigation, including water applied both to agricultural crops and pastures and to recreational lands such as golf courses. Public water supplies represented only about 8 percent of total national water withdrawals. Between 1980 and 1995, the nation's total water withdrawals declined nearly 10 percent to 400 billion gallons per day, including an 11 percent decline in irrigation water use, an 11 percent decline in thermoelectric use, and a 39 percent decline in commercial and other industrial use (Box Figure 1.4). While U.S. population continued to grow steadily, the downturn in water withdrawals suggests some improvements in water-use efficiency, though other factors such as variations in annual precipitation also affect such measures. (See also Part III, Table 6.3)

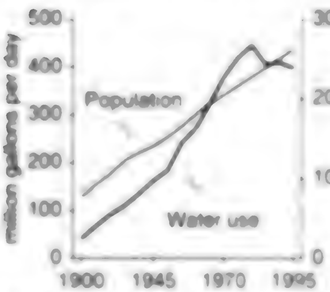
In the case of agriculture, for example, irrigators are using water more efficiently. Nationally, average water rate applications have dropped 14 percent since 1970. Between 1982 and 1992, 11 million more irrigated acres were managed with water conservation systems. Cropping techniques such as terracing can increase the water available for use in a watershed. Conservation plantings can promote infiltration of rainfall, capturing more water for use by agriculture and communities.

Another factor is the decline in irrigation in the West and increase in the East, where irrigation water tends to be used as a supplement.

Groundwater is one of the nation's most important natural resources. About 40 percent of the nation's public water supply and more than 30 percent of the water used for irrigation is provided by groundwater. Groundwater provides 96 percent of the self-supplied domestic freshwater use in the United States. It is the nation's principal reserve of freshwater and represents much of the nation's future water supply.

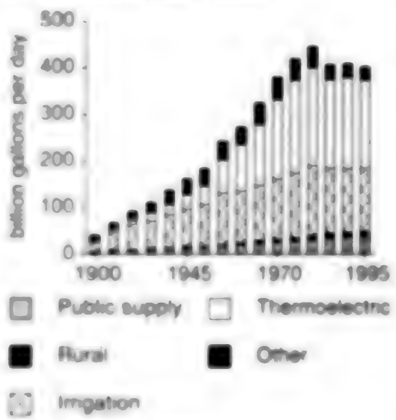
Depletion of groundwater in some regions has reached significant proportions. Moreover, increases in withdrawals from the nation's groundwater systems are expected to occur in future years as a result of increased irrigation in certain regions, water needs for industry and growing urban areas, limited new surface reservoir capacity, and the desire to establish water supply systems that are not easily affected by droughts.

Box Figure 1.3 Population Growth and Water Use in the United States, 1900-1995



Source: See Part III, Table 1.1 and Table 6.3.

Box Figure 1.4 U.S. Water Use by Sector, 1900-1995



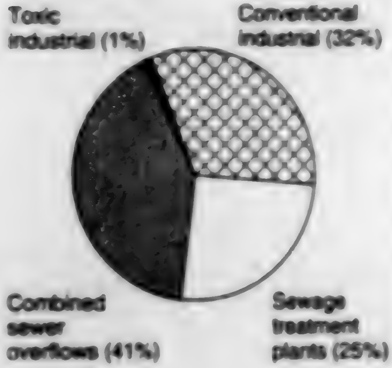
Source: See Part III, Table 6.3.

Water Rights

State law usually governs who has the right to use water and how those rights are administered. In the East, where water is generally abundant, the riparian doctrine is used, which entitles streamside owners to make reasonable use of the water flowing past their land provided that their use does not unreasonably interfere with the use of others.

Under the prior appropriation doctrine in the West, the right to use water is established by putting the water to a beneficial use. When there is not enough water for everyone, users under the riparian doctrine will share reductions proportionately, while those under the prior appropriation doctrine will be apportioned water under the principle of "first in time is first in right."

Figure 1.6 Point Source Discharges, circa 1992-1995



Source: U.S. Environmental Protection Agency, Permit Compliance System, unpublished.
Note: Totals include: sewage treatment plants, 3,318 million pounds in 1992; combined sewer overflows, 5,340 million pounds in 1992; toxic industrial, 146 million pounds in 1995; and conventional industrial, 4,170 million pounds in 1995.

Federal reserved water rights are a special case. The Supreme Court has held that when the United States withdraws land from public domain and reserves it for a federal purpose, by implication it reserves sufficient water to accomplish reservation purposes. The doctrine has its roots in the context of water rights on Indian Reservations, but was later extended to other federal reservations, such as National Parks and Forests.

The Federal Role in Water Quality

The Clean Water Act's National Pollution Discharge Elimination System (NPDES) provides a permitting mechanism to limit the amount of pollution that can be discharged into receiving waters from industrial and sewage treatment plants, as well as from other sources that can affect water quality (Figure 1.6). Technology-based performance requirements have been issued for over 50 kinds of industries; collectively, they reduce pollution loadings from industries by about 90 percent. Municipal sewage treatment plants in most areas are required to provide at least secondary treatment, to assure that 85 percent of conventional pollutants flowing through these plants, such as organic waste and sediment, are removed.

Water quality standards are set by the states for every body of water, subject to EPA approval. These include a designated use (such as drinking water or recreation), specific criteria to protect those

uses, and provisions to prevent degradation of water.

The law also provides funding to help states and local governments protect and improve water quality. The original 1972 act established a construction grants program, in which the federal government agreed to pay up to 75 percent (later reduced to 55 percent) of the construction and design cost for municipal treatment plants. From 1972 to 1990, the program provided nearly $54 billion in federal assistance; state and local governments contributed over $20 billion.

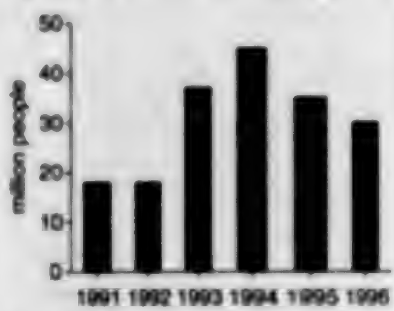
Amendments to the act in 1987 began a transition from grants to loans through state revolving funds. Localities now must repay the cost of construction financing. Federal contributions (83 percent) to the funds are matched by states (17 percent of total capitalization). Although loan support under this program has focused on financing municipal sewage treatment, loans may now be used for stormwater management, wetlands protection, and projects that reduce agricultural and urban runoff, if they are part of a state's Nonpoint Source Pollution Plan.

The transition from grants to loans has meant a substantial increase in the share of wastewater treatment expenditures borne by local governments. The program has also been an effective way to leverage limited dollars. Over a 20-year period, an initial federal investment can result in the construction of up to four times as many projects as a one-time federal grant. With new str[illegible] requirements, state revolving [illegible] projects are completed about [illegible] faster than those funded with grants. The typical cost of a state revolving fund loan is about 30 to 50 percent less than the cost of the same project funded through the commercial bond market. For more on point-source pollution controls, see Chapter Five.

Under the Safe Drinking Water Act, which mandates national primary drinking water regulations, EPA and the states regulate about 55,000 public community drinking water systems that serve over 247 million people. In 1996, 83 percent of the population were served by community systems with no reported violations of drinking water standards, 12 percent were served by systems with one or more violations of maximum contaminant levels (MCLs), and 5 percent were served by systems with violations of water treatment technique standards (Figure 1.7).

Water quality remains a significant problem in the nation's rivers, lakes, and estuaries. According to the 1996 EPA National Water Quality Inventory, which

Figure 1.7 Population Served by CWSs with Violations of Health-based Standards, 1991-1996



Source: U.S. Environmental Protection Agency, Safe Drinking Water Information System, 1997
Note: CWS = Community Water System.

Figure 1.8 Overall Use Support in U.S. Rivers and Streams, 1996

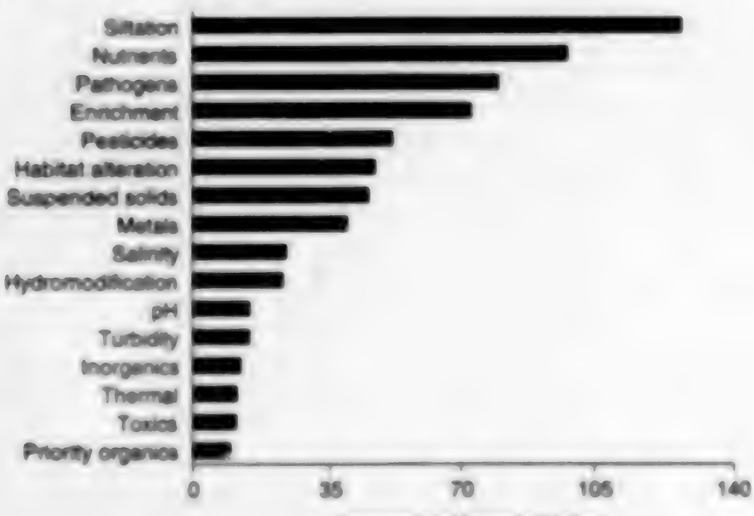
Source: See Part III, Table 6.4
Note: Based on an assessment of 19% of U.S. river and stream miles.

surveyed about 19 percent of the nation's 3.6 million miles of rivers and streams, about 60 percent of surveyed rivers and streams showed good water quality and supported their designated use and 8 percent were in good condition but threatened. About 30 percent were impaired – supporting their designated uses only partially or not at all (Figure 1.8).

One or more sources may impair any given river or stream. Siltation and nutrients were the pollutants most often found in surveyed rivers and streams, each affecting 18 percent and 14 percent, respectively, of all surveyed river miles (Figure 1.9). Agricultural activities were the most widespread source of pollution, generating pollutants that degraded aquatic life or interfered with public use in 25 percent of the surveyed river miles (Figure 1.10).

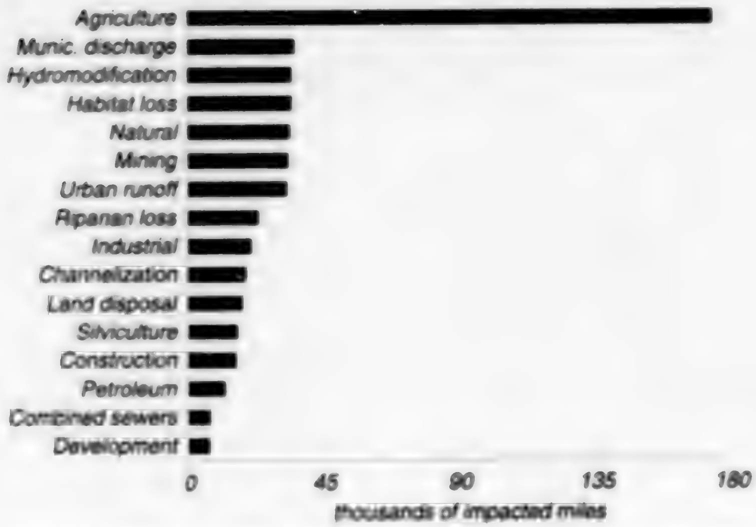
Nonpoint Pollution. It is generally agreed that the framework of pollution

Figure 1.9 Leading Causes of Pollution in U.S. Rivers and Streams, 1996



Source: U.S. Environmental Protection Agency, Office of Water, National Water Quality Inventory: 1996 Report to Congress, Table A4 (EPA, OW: Washington DC, 1998).

Figure 1.10 Leading Sources of Pollution in U.S. Rivers and Streams, 1996



Source: U.S. Environmental Protection Agency, Office of Water, National Water Quality Inventory: 1996 Report to Congress, Table A5 (EPA, OW: Washington, DC, 1998).

control standards, technical tools, and financial assistance provided by the Clean Water Act has greatly reduced water pollution from industries, sewage treatment plants, and other point sources, but for a variety of reasons has been considerably less successful in reducing pollution from nonpoint sources. Other approaches have been effective in reducing nonpoint pollution, but have not been widely implemented. Conservation activities, for example, have generated substantial benefits for water resources by reducing runoff, sediment loads, erosion, and nutrient use.

A wide variety of federal programs are intended to reduce nonpoint pollution. Sources of nonpoint pollution include air deposition, cropland, livestock, urban runoff, storm sewers, construction sites, mining, logging, and drainage from waste disposal sites.

Under the Clean Water Act, EPA has provided over $570 million through fiscal 1997 in grants to states, which are passed through to farmers, ranchers, small businesses and local governments to support the design and implementation of practical measures to address polluted runoff. The Clean Water state revolving fund program is also a significant source of funding for nonpoint pollution control projects, providing $659 million since 1988, with the potential to fund a much larger share.

The Department of Agriculture also has numerous programs that address nonpoint pollution. The 1996 farm bill merged the Agricultural Conservation Program (ACP), Great Plains Conserva-

tion Program, Colorado Basin Salinity Control Program, and Water Quality Incentive Projects into the Environmental Quality Incentives Program (EQIP). EQIP funding is capped at $200 million for each year through 2002. The program is available to farmers and ranchers in priority areas identified through the locally led conservation process and where there are significant threats to water and soil and related natural resources.

CASE STUDIES

The causes of environmental change have varied from river to river, and have included urbanization, industrial development, agriculture, and the construction of dams and canals. In general, it appears that for many rivers pollution was most severe in the 1930 to 1950 period, with gradual improvement or restoration since then. The Delaware River and Bay, the South Florida ecosystem, and the San Francisco Bay-Delta ecosystem provide three contrasting examples.

Case Study: The Delaware River and Bay

Several studies, including a 1975 CEQ report and a study by Ruth Patrick, have described the environmental history of the Delaware River.

Arriving in the Delaware Valley in 1678, the first Quaker settlers built tanneries, brickyards, and glassworks. These were soon followed by forges and furnaces to smelt and shape iron ore and grain mills to grind corn, wheat, and rye. Lumbering became an important industry, with communities on the Bay supplying wood to shipyards and papermills near Wilmington. Commercial fishing and oystering thrived.

By the time of the first Continental Congress in 1774, there was noticeable water pollution in the Delaware. The first water quality survey in 1799 reported that the main sources of pollution were in the Philadelphia area. But the volume of waste was small enough to be assimilated by the river; the water continued to be drinkable and fisheries prospered.

During the 1800s, many large manufacturers chose sites along the river to take advantage of the water and the inexpensive transportation provided by the river and newly built canals. In the early 1800s, E. I. Du Pont, a French chemist, established the first gunpowder mills in the nation on the Brandywine Creek just above Wilmington. The availability of large amounts of water was vital to the success and growth of these enterprises.

The fishing industry continued throughout the century, but many species—shad, striped bass, and sturgeon—began to decline. Catfish almost completely vanished and the population of oysters also declined. Overfishing and dam construction, which prevented upstream migration, probably were the main factors in the decline, but water pollution almost certainly played a role.

By the 1850s, the city of Philadelphia began building sewers to carry wastewater away from city streets, and other communities soon followed suit. But the volume of sewage and industrial waste contaminated water supplies, causing typhoid and other waterborne diseases that preyed on

Philadelphians through the end of the century.

To deal with this public health threat, Philadelphia in 1899 began construction of the world's largest sand filtration plant. Other cities such as Trenton also built filtration plants, but Camden abandoned the Delaware as its source of water and in 1897 drilled over 100 wells into the aquifers underlying southern New Jersey.

During the first decades of the 20th Century, modest attempts at pollution control were overwhelmed by continued municipal and industrial growth. Water quality sunk to probably its lowest level in the period from 1930 to 1950. Only about 20 percent of the total sewage from Camden and Philadelphia was treated; most smaller communities were discharging raw sewage directly into the river. Industrial dischargers were adding to the problem; over 200 industries in Philadelphia alone were annually discharging some 90,000 tons of solid and semisolid wastes into the river or into the sewer system. As dissolved oxygen was depleted, noxious hydrogen sulfide gases were formed, causing waterfront residents in Philadelphia to complain to President Roosevelt as early as 1934. During World War II, fumes of hydrogen sulfide corroded the metal used for naval radar equipment while it was still on the assembly line.

Fishing declined drastically, with annual finfish catches after 1930 dropping to one tenth of the 1900 catch or less. Commercial shad fishing virtually disappeared, and oyster harvests sank to less than one fifth of their former size. The water in the estuary was so dirty that it clogged ships' engines, requiring expensive repairs.

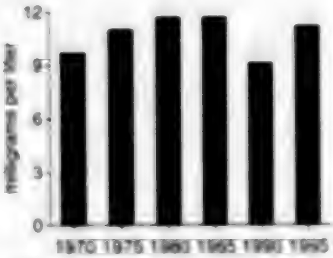
In 1936, the Interstate Commission on the Delaware River Basin was created to encourage the cleanup of the Delaware. Though it had no authority to compel action, this cooperative effort – managed by the states of New York, New Jersey, Delaware, and Pennsylvania – succeeded in recommending minimum water quality standards that all of the member states eventually ratified. Between 1936 and 1942, communities along the river spent more than $10 million to build sewage collection and treatment plants, and by 1946 Philadelphia had embarked on an $80 million sewer improvement and treatment program.

In 1937, Pennsylvania passed the Clean Streams Law, which brought industrial wastes under control. By 1961, 71 percent of Pennsylvania's industries were treating their wastes before discharging them to rivers, compared to just 8 percent in 1941.

By 1964, helped by federal and state funds, all municipalities along the Delaware River Estuary had at least primary treatment. The river's dissolved oxygen content improved, though other indices showed no significant improvement in water quality. Further tightening of water quality standards followed in 1967.

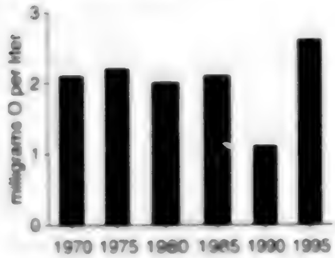
Over the past 40 years, water quality in the Delaware has improved substantially, with the most significant progress since 1980 (Figures 1.11a-1.11f). Though the Delaware is still the site of an enormous concentration of industry – including petroleum refining and petrochemical

Figure 1.11a Mean Annual DO Concentrations in Delaware River, 1970-1995



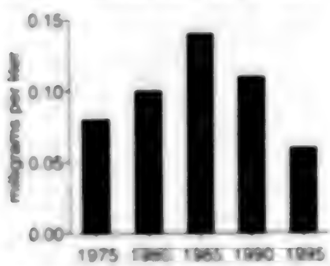
Source: Organization for Economic Cooperation and Development, *Environmental Data Compendium 1997* (OECD: Paris, 1997).
Note: DO = Dissolved oxygen.

Figure 1.11b Mean Annual BOD Concentrations in Delaware River, 1970-1995



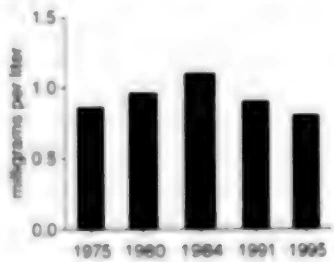
Source: Organization for Economic Cooperation and Development, *Environmental Data Compendium 1997* (OECD: Paris, 1997).
Note: BOD = Biochemical oxygen demand.

Figure 1.11c Mean Annual Phosphorus Concentrations in Delaware River, 1975-1995



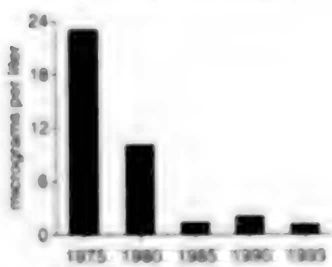
Source: Organization for Economic Cooperation and Development, *Environmental Data Compendium 1997* (OECD: Paris, 1997).

Figure 1.11d Mean Annual Nitrate Concentrations in Delaware River, 1975-1995



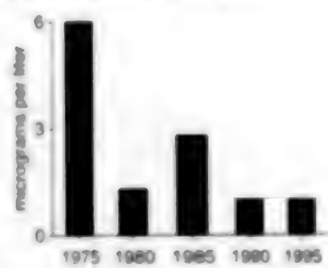
Source: Organization for Economic Cooperation and Development, *Environmental Data Compendium 1997* (OECD: Paris, 1997).

Figure 1.11e Mean Annual Chromium Concentrations in Delaware River, 1975-1993



Source: Organization for Economic Cooperation and Development, *Environmental Data Compendium 1997* (OECD: Paris, 1997).

Figure 1.11f Mean Annual Lead Concentrations in Delaware River, 1975-1995



Source: Organization for Economic Cooperation and Development, *Environmental Data Compendium 1997* (OECD: Paris, 1997).

plants, papermaking, chemical manufacturing, metal processing, and food processing – the dissolved oxygen level has improved enough to maintain aquatic life in all sections of the river. Commercial fishing, including a resurgence of the shad fishery, is continuing. The Delaware is extensively used as a recreational resource. Greenway trails are being established, and public access to the Delaware Estuary has increased as a result of new public parks in the watershed.

Although there have been dramatic improvements in the water quality in the river, problems still exist. For example, water quality does not meet the standard for swimming in the Philadelphia and Camden sections of the river, primarily due to bacteria. Despite increased numbers, levels of some anadromous fish have not reached historic levels due to habitat perturbations and lack of coordinated management plans. Elevated levels of toxics have been detected in sediments, water column, and tissues of organisms, and fish consumption advisories exist in all three states. Heavy use of surface and groundwater places a significant demand on the long-term water supply in the watershed. Sprawl development causes habitat fragmentation and consumes large amounts of natural habitat.

The Delaware Estuary Program was established in 1988 under the Clean Water Act to address these and other issues affecting the Delaware watershed. The program brought together stakeholders from all three states to identify the most important issues and develop a plan of action. In 1996, the Comprehensive Conservation and Management Plan (CCMP) for the Delaware Estuary was signed by the three governors and EPA. Implementation of the plan is currently underway.

Case Study: South Florida Watershed

South Florida – the vast watershed beginning at the headwaters of the Kissimmee River, passing through Lake Okeechobee and the Everglades, and spilling out into Florida Bay – provides an interesting contrast to the history of the Delaware Basin.

Much more so than the Delaware, the south Florida watershed has a long history of attempts to physically modify the rivers and ecosystem to accommodate regional development. Changes began in 1882, with the channelization of the Caloosahatchee River and its connection to Lake Okeechobee, resulting in a new westward outflow from the lake. Four canals were cut from the lake southeast through the Everglades to the Atlantic. In 1916, a fifth canal was constructed from the lake due east to the ocean, and the southern rim of the lake was diked and leveed for agriculture.

Flood control and mosquito control were the two primary reasons for the diking, draining, and channeling of the Kissimmee River, Lake Okeechobee, and the Everglades. Major drainage control systems were built between the late 1930s and the 1960s as a result of the very damaging hurricanes of 1926, 1928, 1947, and 1948. The 1928 hurricane was especially destructive, causing Lake Okeechobee to overflow and killing some 2,500 people.

These disasters spearheaded the heightening of the levee around Lake Okeechobee, improving the linkage of the lake with the Caloosahatchee River, digging the St. Lucie Canal, channelizing the Kissimmee River, constructing the eastern perimeter levee, and creating the Central and Southern Flood Control District (later to become the South Florida Water Management District).

All of these changes had unforseen environmental consequences, including uncontrolled drainage that threatened freshwater supplies, inadequate flood control in wet years, huge muck fires in dry glades, and saltwater intrusion. To deal with these new problems, Congress in 1948 authorized a massive new project that included a 100-mile levee to protect lands to the east of the Everglades from flooding and saltwater intrusion. The project also created an agricultural area and three water conservation areas separated by levees and regulated by canals and pump stations. The water conservation areas provide water to Everglades National Park, which was authorized in 1934 and established in 1947.

The reshaping continued in the 1960s. The Kissimmee River, which in its natural state included 103 miles of meandering river and 35,000 acres of wetlands, was reduced to a canal 56 miles long. Transportation projects such as Alligator Alley and the Tamiami Trail blocked the southward movement of water.

These massive changes had an enormous environmental impact. The wading bird population in the ecosystem may have declined by as much as 90 percent since the turn of the century. South Florida now has 56 federally listed endangered and threatened species — notably including the Florida panther — and 29 candidate species.

The growth of agriculture, which brings nutrient discharges into a nutrient-poor ecosystem, has caused severe water quality problems and changes in vegetation; nutrient over-enrichment is considered the main pollutant in the ecosystem. Native vegetation in many areas has given way to dense stands of cattails, resulting in further decreases in populations of local wading birds and other native species.

Hydrological changes and agricultural practices also are affecting Florida Bay, where massive seagrass die-offs, algal blooms, and declines in populations of fish, mangroves, and other species have been documented. Explanations range from hypersalinity (due to diverted freshwater flows) and pollution to the natural impacts of hurricanes and drought.

Exotic species, including Australian melaleuca and Brazilian pepper, are proving to be a formidable long-term problem. Melaleuca was introduced intentionally for its ability to dry up marshes, and both it and Brazilian pepper tend to form dense stands that crowd out native species.

The effort to restore the Everglades ecosystem, which began in 1983 and is continuing today, is described in Chapter Six.

Case Study: The Sacramento-San Joaquin River System

San Francisco Bay and the Delta combine to form the West Coast's largest estu-

ary. The estuary conveys the waters of the Sacramento and San Joaquin rivers to the Pacific Ocean. It encompasses roughly 1,600 square miles, drains over 40 percent of the state (60,000 square miles), and contains about five million acre-feet of water.

The estuary watershed provides drinking water to 20 million Californians and irrigates 4.5 million acres of farmland. It also hosts a rich diversity of aquatic life. Each year, two thirds of the state's salmon pass through the Bay and Delta, as do nearly half of the waterfowl and shorebirds migrating along the Pacific Flyway. In addition, the estuary's water enables the nation's fourth-largest metropolitan region to pursue many activities, including shipping, fishing, recreation, and commerce.

Before western water development began, about 40 percent of California's runoff converged into the Sacramento-San Joaquin Delta on its way to San Francisco Bay and the Pacific Ocean. A series of reservoirs, canals, and pump stations now capture winter rains and snowpack for diversion to Southern California, the San Joaquin Valley, and parts of the Bay area via the massive State Water Project (SWP) and Central Valley Project (CVP). The water delivered through these huge systems has enabled the state's semiarid Central Valley to become one of the nation's prime agricultural areas and has provided water to the rapidly growing population in Southern California.

These North-South transfers have come at a price for the North. For example, Delta fishery resources have been devastated. Fewer than 500 wild winter run salmon have returned to spawn in the Upper Sacramento in recent years, compared to 80,000 annually 20 years ago. Causes of these dramatic declines include overfishing, loss of habitat, water pollution, dams, levees, obstructions, and drought.

Water quality in the Delta also is at risk. Concerns include salinity intrusion into the western Delta from San Francisco Bay, wastewater discharges that contain chemical pollutants, and the inflow of agricultural drainage water that may contain pesticide residues and other toxic agents. The state is legally required to provide an adequate amount of freshwater to the Delta, but this requirement may conflict with water transfers and local consumptive uses. This is especially true during drought, when there may not be enough water to fulfill all demands.

The conflict between water requirements in the Delta and the transfer of water supplies to the southern part of the state has proved to be one of the most controversial water problems in the West. In 1982, California voters defeated a referendum to build the "Peripheral Canal" around the Delta to improve the system's efficiency. Northern Californians overwhelmingly rejected the proposal, apparently fearing that the Delta environment would not be adequately protected and that populous Southern California was attempting another "water grab." Although there was more support in Southern California, many in that part of the state feared the project's high cost.

In 1987, as part of the National Estuary Program, EPA launched a San Fran-

cisco Estuary Project (SFEP). After five years, the project's public-private partnership approach reached its initial goal of developing a Comprehensive Conservation and Management Plan (CCMP) for the estuary. The CCMP addresses five critical issues: the decline of biological resources, pollutants, freshwater diversions and altered flow regime, dredging and waterway modification, and intensified land use. For each of these areas, the CCMP defines the problem, evaluates the existing management structure, identifies goals for correcting the problem, provides a broad recommended approach for achieving the goals, and provides specific actions and objectives for carrying out the recommended approach.

However, many aspects of the San Francisco Estuary Project were not implemented. Thus, in 1993, state and federal agencies were being forced to make regulatory decisions regarding implementation of the Clean Water Act and the Endangered Species Act. In December 1994, representatives from the state and federal government signed the Bay-Delta Accord, specifying how state and federal agencies would meet their regulatory obligations until a joint state-federal comprehensive water management and ecosystem restoration program could be developed. The accord led to creation of the CALFED Bay-Delta Program.

Specific concerns addressed by this program include: water quality for both drinking and agriculture, the reliability of water supplies, the deterioration of fish and wildlife populations and habitat, and the Delta levee system, which is now vulnerable to natural disaster as a result of neglect and a lack of financial resources for needed maintenance. A federally chartered Bay-Delta Advisory Council, with 34 members from throughout the state, provides regular guidance and is one of many avenues for public input.

The CALFED Bay-Delta Program is carrying out a three-phase process to achieve broad agreement on comprehensive solutions for the Bay-Delta system. During Phase I in 1995 and 1996, the program worked to clearly define the fundamental problems in the Bay-Delta ecosystem, developed a mission statement and general goals, and developed an initial set of alternative actions.

During Phase II, in compliance with the National Environmental Policy Act and the California Environmental Quality Act, the program is preparing a program-level environmental impact statement to identify impacts associated with the various alternatives. After selection of a preferred alternative, the third phase begins with a site-specific environmental review. During Phase III, which will begin in early 1999 and continue for perhaps 20 to 30 years, the preferred alternative will be implemented.

THE RIVER RUNS DRY

Across much of the nation, droughts and water scarcity are always a risk.

During the extreme drought in the Mississippi watershed in 1988, for example, the barge system was severely tested. The Mississippi-based barge industry is one of the nation's major conveyors of bulk commodities. Some 300 tow and

barge companies haul nearly half of the entire Midwestern grain crop plus about 40 percent of the nation's petroleum and 20 percent of its coal. All told, the industry earns about $1 billion per year.

The drought began in the winter of 1987 and continued through the following summer. By mid-June, 83 percent of the river basin was experiencing a severe drought. On June 8, a barge ran aground near St. Louis, marking the first in a series of navigational disruptions.

Fully loaded barges require minimum water levels of 9 feet to operate safely. In 1988, even carefully controlled and timed water releases by the Army Corps of Engineers could not maintain such levels.

Under such circumstances, river managers had to fall back on other strategies, including dredging the blocked areas, limiting the number and weight of the barges pulled by a towboat, releasing more water from upstream dams, or using alternate navigation routes or modes of transportation.

In 1988, managers drew on all of these strategies and more. In addition to periodic dredging, some barge traffic was diverted to the Tennessee-Tombigbee Waterway. Some grain shipments were shifted to alternate ports and routes on the Great Lakes instead of the Mississippi. By the time of the closing of the Ohio River on June 14, 700 barges were backed up at Mound City, a major grain port. With the barges not running and no empty barges arriving, grain piled up at the port. More than $1 million worth of corn was simply stored on city streets because there was no more room in the grain elevators.

At one point, the Governor of Illinois proposed to triple the normal water releases from Lake Michigan for a limited time to help restore Mississippi River levels. Governors of four Great Lakes states threatened court action over the issue, and the Canadian Ambassador delivered a formal protest to the U.S. State Department. In the end, the Governor of Illinois dropped the proposal.

All told, the economic losses due to disrupted barge transportation may have reached $1 billion.

For much of the area west of the Mississippi, water scarcity is a fact of life that has had an important impact on the region's development.

In February 1991, after four years of severe drought in California, Governor Pete Wilson established a Drought Water Bank to help deal with the water shortage. The bank's charge was to purchase water from willing sellers and sell it to entities with critical needs.

Water for the bank was acquired through land fallowing (i.e., not planting or irrigating a crop), using groundwater instead of surface water, and transferring water stored in local reservoirs. Most of the 351 contracts negotiated were for fallowing land, but the largest acquisition came from transferring stored water. Of the 820,000 af purchased by the bank, about 400,000 af were disbursed for critical needs and about 260,000 af were carried over into 1992. Some of the excess water acquired was lost in conveyance or was used to maintain water quality standards in the Delta. The Water Bank initiative continued through 1993.

A nearly dried up stock pond in Brackettsville, Texas, in August 1980.

Photo Credit:
USDA—95CS2427

Overall, the California Water Bank was considered an effective effort to reallocate water. The adverse economic impacts were minimal, and the Bank created substantial gains for California's agriculture and economy. But the effort was not without criticism. Some local communities worried about the possible impact on their tax base, and some rural communities feared that water banking could accelerate their demise. Many were concerned that urban areas could use the Water Bank as an excuse for avoiding water development, conservation, or reclamation programs.

Elsewhere in the water-short West, supplies have been augmented through the transfer of water from one river basin to another by canal, aqueduct, or pipeline. For example, more than 812 million cubic meters of water are transferred annually from the basins of the Colorado, San Juan and Colorado rivers on the Western Slope across the Continental Divide to the Eastern Slope of the Colorado, where 80 percent of the state's population resides.

Groundwater has been one answer to the water supply problem in the West. About 30 percent of the groundwater used for irrigation in the United States is pumped from the High Plains aquifer, which underlies parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming. In 1990, 15.6 million acre-feet of water was withdrawn from the aquifer to irrigate approximately 14 million

acres. This intense use has led to significant declines from predevelopment water levels in many areas (Figure 1.12). In the central and the southern High Plains, declines have exceeded 100 feet. Smaller, less extensive declines have occurred thus far in the northern High Plains, where irrigation has been practiced for a shorter time.

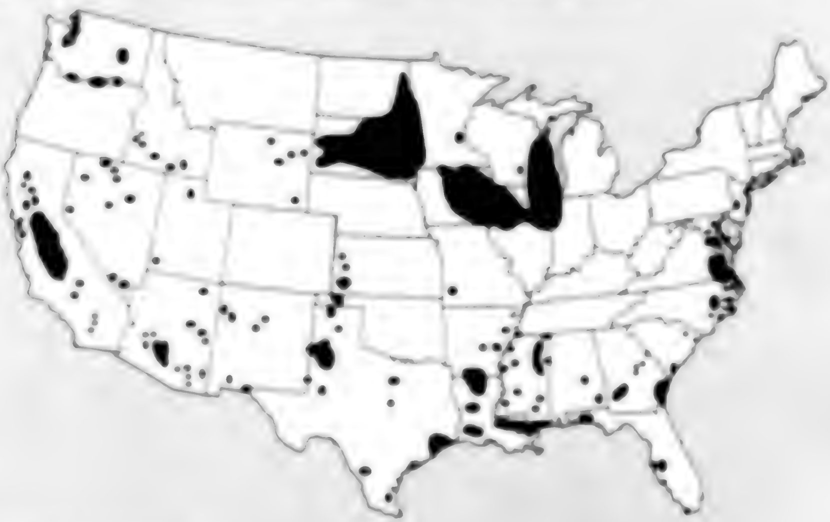
The Southwest also faces a fundamental imbalance between water supplies and demand. In an average year, there is insufficient precipitation to meet demand (Figure 1.13). These areas use more than 100 percent of their annual average precipitation and either import water from other watersheds or mine groundwater to meet annual demand. Water use conflicts have existed in these areas for decades, but the conflicts have intensified as demands have increased.

Where water demand exceeds 75 percent of available precipitation, water use conflicts are just beginning to emerge and will likely escalate if development should increase demand. Much of the East and parts of the Northwest have abundant freshwater supplies, but even these areas have experienced water use conflicts and more may arise. Continued growth will require some combination of importing more water and/or managing water more efficiently.

Case Study: Water Conflicts in the South

Even in the eastern region of the nation, where water is relatively abun-

Figure 1.12 Areas of Water Table Decline in the United States



Source: U.S. Geological Survey

Figure 1.13 Freshwater Consumption as a Percentage of Local Average Precipitation

Source: USDA/NRCS and Texas Agricultural Experiment Station, Agricultural Research Service, HUMUS Project [illegible]

dant, increasing demand and pressures to manage water for a wider array of uses can lead to conflicts.

In the late 1980s, for example, the Corps of Engineers asked the Congress for permission to reallocate 120 million gallons of water daily from Lake Lanier to meet metro Atlanta's growing water needs. The state of Alabama, worried about the impact of this proposal, filed suit in 1990 in U.S. District Court to bar the reallocation. Florida, which shared Alabama's concerns, later became a party to the suit.

In 1992, the Corps and the governors of Georgia, Alabama, and Florida signed a Memorandum of Agreement (MOA) that preserved the status quo while the states negotiated a formal agreement about how much water each state can take from the Chattahoochee and Flint rivers. In the meantime, the states embarked on a comprehensive study, including both the Apalachicola-Chattahoochee-Flint and the Alabama-Coosa-Tallapoosa river basins. The research effort includes studies of the demand for water resources over the next several decades, the historic and present availability of surface and groundwater, future trends in population and employment, the environmental needs of the basins, navigation-related water needs, and recreation-related water needs. The goal is to develop strategies to guide water management decisions and a mechanism for coordination of those decisions.

In March 1997, Georgia agreed to enter into two interstate compacts that will divide water from the region accord-

ing to an allocation formula. A compact with Alabama and Florida will divide the waters of the Chattahoochee, Flint, and Apalachicola rivers. Another compact with Alabama will divide the waters of the Alabama, Coosa, and Tallapoosa rivers. The compacts must be approved by the state legislatures and ratified by Congress.

In order to prevent delays in implementation, the allocation formulas will be worked out by the members of the compact commission after the legislation is passed. The goal of the allocation effort is to establish an equitable allocation of the available water for various uses, including drinking, navigation, power generation, recreation, industry, and other purposes, and to find a reasonable balance between upstream interests such as metro Atlanta and downstream interests such as farming and fishing industries.

THE RIVER RUNS OVER

An important thread of the nation's history deals with efforts to tame the uncontrollable nature of rivers through the construction of dams, channels, levees and dikes. Now highly regulated and controlled, rivers nevertheless are still capable of overflowing all such structures and inflicting much suffering on surrounding communities.

The Great Flood of 1993 in the upper Mississippi and Missouri rivers revived a national debate about floodplain management and federal policies that dates back many decades (Box 1.3).

The debate has many facets, including whether the construction of an extensive system of federal and non-federal levees and dikes along the river has actually worsened the severity of the flood by reducing available floodplain area, whether federal policies promote excessive floodplain development, and whether people choosing to live on floodplains should bear a greater share of the risk inherent in that decision.

The private and uncontrolled construction of levees and dikes along the river in its early history raised some difficult questions. Every such structure built

Box 1.3
What is a Floodplain?

Floodplains are the relatively low and periodically inundated areas adjacent to rivers, lakes, and oceans. Floodplain lands and adjacent waters combine to form a complex, dynamic physical and biological system that supports a multitude of water resources, living resources, and societal resources. Floodplains provide the nation with natural flood and erosion control, water filtering processes, a wide variety of habitats for flora and fauna, places for recreation and scientific study, and historic and archeological sites.

Estimates of the extent of the nation's floodplains vary. In 1977, the U.S. Water Resources Council estimated that floodplains comprise about 7 percent, or 178.8 million acres, of the total area of the United States and its territories.

Source: *Sharing the Challenge.*

along one shore could increase the volume and speed of flows on the opposite shore or at sites downstream, thus creating a situation in which the effort to protect one community might worsen the damage for others.

The need for greater coordination became dramatically evident after the monumental Mississippi River flood of 1927, which demonstrated the inadequacy of the flood control efforts that began in the early 19th Century and that had grown over the years to an uncoordinated amalgam of public and private systems (Box 1.4). In response, the 1928 Flood Control Act and the 1936 Flood Control Act codified a federal interest in the coordinated development and installation of flood damage reduction measures.

Starting in 1936, the Corps focused on major rivers and the development of congressionally approved plans for reservoirs, levees, channelization, and diversions. In the upper Mississippi River basin, the Corps constructed 76 reservoirs controlling a drainage area of almost 570,000 square miles and containing a total flood storage volume of 40 million acre-feet of water. In addition, the Corps constructed over 2,200 miles of levees in the upper Mississippi basin. River communities also were protected by an estimated 5,800 miles of non-federal levees.

Did the federal effort help reduce the damages during the 1993 flood? The June 1994 report of the Interagency Floodplain Management Review Committee concluded that the federal system had worked essentially as designed and thus significantly reduced the damages to population centers, agriculture, and industry. The Committee estimated that reservoirs and levees built by the Corps stored 22.2 million acre-feet of water during the period of peak flooding and that federally constructed levees had prevented substantial damages to communities such as St. Louis, Kansas City, and the low-lying areas of Rock Island and Moline, Illinois. All told, the committee estimated that Corps-built reservoirs and levees prevented more than $19 billion in damages, and that watershed projects built by the Soil Conservation Service (now NRCS) saved an estimated additional $400 million.

Levees can cause problems at some critical reaches by backing water up on other levees or lowlands, but the Committee concluded that flooding in 1993 would have covered much of the floodplains of the main stem lower Missouri and upper Mississippi rivers whether or not levees were there. A modeling analysis estimated that if all the non-urban levees were absent, the peak stage at St. Louis in 1993 would have been reduced by 2.5 feet. Even at that level, the flood would have been more than 17 feet above flood stage and almost 4 feet higher than the previous known maximum level recorded during the flood of 1973.

The Committee concluded that "levees did not cause the 1993 flood. During large events such as occurred in 1993 levees have minor overall effects on floodstage but may have significant localized effects."

The Committee, however, did conclude that the uncoordinated development of private and other non-federal levees throughout the Upper Mississippi

Box 1.4
The Great Mississippi Flood of 1927

In *Rising Tide*, author John M. Barry writes eloquently of the Great Mississippi River flood of 1927, which devastated a vast area and forced over a million people out of their homes.

Greenville, Mississippi, was protected from direct assault by the river by a large levee. The major break in the levee occurred north of Greenville, long before the flood waters described reached the city. The city was also protected by a smaller, local levee. A break in this smaller levee is described here by Barry. The flooding in Greenville began on April 21, 1927.

"The Greenville protection levee stood eight feet high. The water paused briefly, then ripped the levee apart as smootly as if unzipping it.

"Then came the chaos. Water roared and hissed, the fire whistle blasted, church bells clanged, animals barked and neighed and bellowed in terror. In Newtown, the black neighborhood closest to the protection levee, hundreds of families began to wade through the rising water to the Mississippi levee, the highest ground in the Delta.

"Rescuers were depositing thousands of refugees from all over the Delta on the levee, to join the city's own thousands already there. Farmers moved cattle, mules, horses, and pigs to the levee as well. The Mississippi River lay on one side, the flood on the other. The levee crown was only 8 feet wide, its landslide slope an additional 10 to 40 feet wide before touching water. A line of people already stretched north from downtown for more than a mile.

"Martial law solved little. Virtually the entire county was underwater, as much as 20 feet of water. The current everywhere was ferocious. People took shelter in railroad boxcars, in the upper stories of cotton gins, oil mills, houses, and barns. Thousands clung to roofs or trees, or sat on the levee awaiting pickup.

Weeks after the levee broke, water was still pouring through both the Mounds Landing break and the city's protection levee."

Source: Barry, John M., *Rising Tide: The Great Mississippi Flood of 1927 and How it Changed America* (Simon and Schuster, New York, 1997).

Basin failed to provide a soundly engineered flood damage reduction system for the basin. It also noted that levees provide only a fixed level of protection and are subject to overtopping during larger floods, a fact that many in the basin had failed to understand.

A second issue in the debate is whether federal policies are actually creating incentives for development in floodplains. Critics point to the fact that there were some 10 million homes in the 100-year flood plain and to cases like that in Chesterfield, Missouri, where an industrial park sited behind an agricultural levee suffered extensive damage during the 1993 flood. All told, about $390 billion in property was thought to be at risk.

While some federal programs did indeed seem to reduce the risk of floodplain development, it was apparent that many of those at risk failed to participate in these programs. For example, the Committee found that only 20-30 percent of eligible homeowners and local governments were enrolled in the National Flood Insurance Program. They concluded that the fact that communities

Residents of Louisa County in Muscatine, Iowa, wade through a flooded-out neighborhood in July 1993.

Photo Credit
USDA—93CS0380

choosing not to participate still received substantial disaster assistance was one of the factors explaining the low enrollment. "Provision of major federal disaster assistance to those without insurance creates a perception with many floodplain residents that purchase of flood insurance is not a worthwhile investment," the Committee found. Critics also noted that there were many other federal post-disaster assistance programs available. These include grants and Small Business Administration loans for homeowners struck by catastrophic flooding; compensation to farmers under the crop insurance program for the value of crop losses; and federal public assistance grants to local governments to rebuild damaged public buildings and infrastructure.

The Committee concluded that "individual citizens must adjust their actions to the risk they face and bear a greater share of the economic costs." They recommended that the federal government improve its marketing of flood insurance and enforce lender compliance rules and "reduce the amount of post-disaster support to those who were eligible to buy insurance but did not to that level needed to provide for immediate health, safety, and welfare."

The report also suggested that the administration "give full consideration to all possible alternatives for vulnerability reduction, including permanent evacuation of floodprone areas" and "creation of additional artificial and natural storage."

In short, the priorities should be: first, avoiding inappropriate use of the floodplain; second, minimizing vulnerability to damage through both structural and nonstructural means; and third, mitigating flood damages when they do occur.

In the wake of the flood and the interagency report, the Clinton administration made substantial revisions to federal floodplain management policies and programs. The emphasis of the reforms is to reduce the loss of life and property caused by floods and to restore the natural resources and functions of flood plains.

In September 1994, Congress and the administration agreed on a package of amendments to the National Flood Insurance Program. The reforms extended the waiting period that applies before flood insurance coverage becomes effective from 5 to 30 days, increased the dollar amount of flood insurance coverage available for residences from $180,000 to $250,000, and prohibited post-disaster support to those who could have purchased flood insurance but did not. The amendments also incorporated the protection of natural resources and functions of floodplains into the program's community rating system, as an incentive to reduce insurance premiums in communities with exemplary floodplain management programs.

The Administration and Congress also agreed in 1994 on reforms to the crop insurance program that provided for catastrophic crop insurance protection. Other 1994 legislation required communities to develop and implement floodplain management plans in association with the construction of a Corps of Engineers flood damage reduction project.

The Administration implemented a marketing strategy called "Cover America" designed to improve participation in the flood insurance program. In less than two years, the new strategy contributed to a 22 percent increase in the number of households signed up for the program.

To encourage responsible rebuilding in the floodplain in the aftermath of the 1993 Midwest floods, the federal government provided funds to acquire, relocate, or elevate over 12,000 flood-damaged properties in about a dozen states. In some cases, entire communities, such as Valmeyer, Illinois, were relocated. Over 40 towns asked for at least some real estate to be bought by the relocation program. Several communities in the Midwest that flooded again in 1995 were spared repetitive and expensive flood damage as a result of the relocation and buy-out program. Most of the funding came from the Department of Housing and Urban Development's Community Development Block Grant program. The flexibility of the CBDG program allows it to play a major role in repair and restoration efforts, as well as in acquisition, relocation, and replacement of damaged properties.

The Department of Interior's Fish and Wildlife Service (FWS), through its National Wildlife Refuge land acquisition and Partners for Wildlife programs, also is participating in the new floodplain initiatives. To restore and protect fish and wildlife habitats of national importance, FWS made extensive use of voluntary cooperative agreements with private

landowners, local soil and water conservation districts, The Nature Conservancy, Ducks Unlimited, and other organizations.

To respond to landowners and levee districts who sought alternatives to restoring flood-damaged lands to pre-flood conditions or repairing levees, the Administration has taken several steps. First, it implemented the Emergency Wetlands Reserve Program. In situations where the cost of levee repair and land restoration was greater than the agricultural value of the land, landowners could now choose to restore the lands as wetlands, instead of trying to rehabilitate the lands for agricultural production. This option not only gave the landowners direct benefits in helping to extricate them from flood-prone lands, but benefited the surrounding areas by adding more wetlands and reducing the region's vulnerability to flooding. Since the 1993 Midwest floods, NRCS has restored and acquired easements on about 86,000 acres in the Mississippi and Missouri river basins. NRCS will be enrolling an estimated additional 5,800 acres in 1996, bringing the total to 92,000 acres.

In 1996, the Administration broadened its authority under emergency flood control repair and restoration law to allow consideration of non-structural alternatives to levee repairs. After a flood has damaged levees, the Corps of Engineers can now assist landowners in exploring the most efficient way to reduce future flood risk instead of being limited strictly to rebuilding to pre-flood conditions.

Civilian volunteers and National Guard personnel build a sandbag levee at Valley Junction, Iowa trying to stop flooding of the Raccoon River in July 1993.

Photo Credit
USDA—93CS0295

The Administration has created interagency task forces that meet after a flood to coordinate in planning structural and non-structural levee repairs and associated restoration. These task forces pool expertise from throughout the government to advise and assist landowners.

In the 1996 farm bill, some of the Administration's initiatives on floodplain management were made permanent and broadened. For example, the Emergency Wetlands Reserve program's option to retire lands voluntarily with a floodplain easement was added to the Emergency Watershed Protection program. The bill also created a new Flood Risk Reduction program, in which farmers could request that USDA offer them their projected future farm program benefits up-front for farm acreage located within the floodplain. The goal of the program is to remove any incentives created by USDA programs that may encourage intensive new row-crop production in floodplains. In this way, farmers can easily move to more suitable lands located in less vulnerable areas.

The Administration also adopted a number of measures to accelerate assistance, response, and recovery. These measures include pre-deploying material and supplies in anticipation of a flood, allowing the Corps of Engineers to implement a "quick repair option" for severely damaged levees, to provide short-term protection while the larger restoration is under planning and design, and expediting the Federal Highway Administration's procedures to provide the states with the funds necessary to begin repairs to Federal-aid roads and bridges damaged by disasters.

The 1993 flood led to significant changes in floodplain management, decreasing incentives for floodplain development, providing new alternatives for floodplain use, increasing enrollment in the National Flood Insurance Program, and expediting federal assistance and recovery programs. The Administration is continuing to refine its flood and floodplain management efforts.

In short, American rivers formed the backbone on which we built a nation. From our early days as a country, the importance of water and waterways was clear, but only recently did we understand that development and pollution could devalue and destroy these precious resources. Today, a shift to thinking about rivers in a much broader context, both environmentally and in terms of governance, has created not only new attitudes but new institutions and mechanisms for decision-making. Broader participation characterizes these new approaches. Chapter Two looks at some of these efforts.

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CHAPTER TWO

Charting New Waters

Three challenges to further environmental progress have emerged in the 1990s:

- Remaining environmental problems tend to be diffuse in origin and require the combined efforts of many parties to resolve;

- All the resources in a particular place — air, water, land, and living resources — need to be considered as interconnected parts of an ecosystem; and

- Not all parts of the country have the same problems or need the same kinds of solutions.

Wrestling with these problems has produced a variety of initiatives with different names but generally similar approaches — community-based environmental protection, watershed-based environmental protection, and ecosystem management.

All of these approaches have a few key points in common. One is a geographic focus that results in a comprehensive approach to environmental protection, identifying priority problems such as air, water, or land issues — or a combination of these concerns. Geographic boundaries also facilitate an approach that looks beyond facility-by-facility progress and identifies overall environmental improvements and trends.

These approaches rely heavily on partnerships and stakeholder involvement. Encouraging involvement by all levels of government, public interest groups, industry, academic institutions, private landowners, concerned citizens, and others is now widely viewed as an important factor in the success of any environmental protection effort. In many cases, several federal agencies are working together in these partnership efforts.

Since the 1980s, federal, state, tribal, and local governments have been adopting the watershed protection approach. The approach focuses on hydrologically defined drainage basins — watersheds — rather than areas defined by political boundaries (Box 2.1). It encompasses not only the water resource — streams, rivers, lakes, estuaries, and aquifers — but all the land from which water drains to the resource. Taking a watershed approach thus means thinking about the connection of all the land areas within that watershed to a basin's water resources.

An EPA effort, for example, began with several large-scale programs dealing with geographic areas, including the

Box 2.1
The Nation's Watersheds

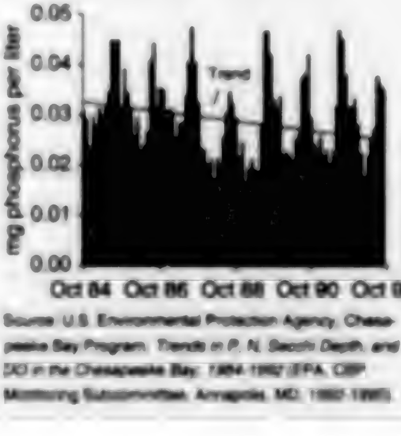
Under a system developed by the U.S. Geological Survey, the nation is divided into successively smaller hydrologic units, which are classified into four levels. The first level divides the nation into 21 major geographic regions, based on surface topography, and contain either the drainage area of a major river, such as the Missouri region, or the combined drainage areas of a series of rivers. The second classification divides the 21 regions into 222 subregions. A subregion includes the area drained by a river system, a reach of a river and its tributaries, a closed basin, or a group of streams forming a coastal drainage area. The third level further divides many of the subregions into accounting units. Cataloging units, the fourth and smallest level in the hierarchy, are a geographic area representing part or all of a surface drainage basin. Almost all cataloging units are larger than 700 square miles.

Chesapeake Bay Program, the Gulf of Mexico Program, the Great Lakes Program, and the National Estuary Program, and is evolving to a more pervasive application of watershed management through technical and institutional support.

The Chesapeake Bay Program identified nutrient over-enrichment in the Bay as a major cause of ecological and economic damage. In 1992, the states of Pennsylvania, Maryland, Virginia, and the District of Columbia committed to set specific nutrient reduction goals for each of the Bay's major tributaries and to develop strategies to achieve those goals. The overall goal is to reduce controllable nitrogen and phosphorus levels in the Bay by 40 percent below the 1985 level by the year 2000.

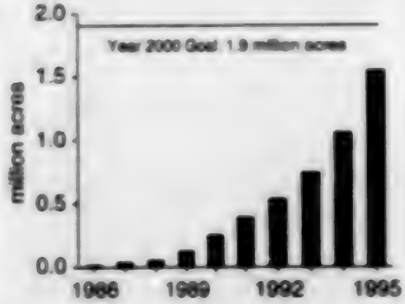
A ban on phosphate detergents in the Bay states has helped to reduced phosphorus entering the Bay by 16 percent since 1985 (Figure 2.1). Biological nutrient removal is currently being used to remove nitrogen at 33 sewage treatment plants throughout the Bay watershed. Between 1985 and 1993, nutrient management plans and erosion and runoff control measures were initiated on over 1.5 million acres of farmland in the Bay watershed in Maryland, Pennsylvania, and Virginia (Figure 2.2). In July 1994, 25 federal agencies made a variety of formal commitments, especially for federal lands within the watershed, to support pollution reduction in the Bay.

Figure 2.1 Mean Monthly Phosphorus Concentrations in Chesapeake Bay, 1984-1992



Source: U.S. Environmental Protection Agency, Chesapeake Bay Program, *Trends in P, N, Secchi Depth, and DO in the Chesapeake Bay: 1984-1992* (EPA, CBP Monitoring Subcommittee, Annapolis, MD, 1992-1993).

Figure 2.2 Acres Under Nutrient Management in Chesapeake Bay Watershed, 1986-1995



Source: U.S. Environmental Protection Agency, Chesapeake Bay Program Office (based on data provided by Maryland, Pennsylvania, and Virginia).

The Gulf of Mexico program includes projects to identify unique and important areas throughout the Gulf that need to be managed or protected to maintain their essential qualities. In Mobile Bay several projects are underway to demonstrate how water quality can be improved by restoring salt marsh and sea grass habitats and to control nonpoint pollution affecting coastal shellfish waters.

For each of the five Great Lakes, the United States and Canada have agreed to develop and implement Lakewide Management Plans (LMPs). The primary goal of these plans is to reduce both point and nonpoint source pollution that threatens the lakes' primary uses. The plans emphasize pollution prevention and other issues such as habitat loss and threats to protected species. A key element of each plan is the integration of federal, state, provincial, and local programs. In addition, Remedial Action Plans (RAPs) are being developed for 43 specific areas of concern in the Great Lakes.

The National Estuary Program (NEP), established in 1987, is a voluntary program that brings communities together to protect and restore their estuaries. Currently, 28 estuaries are part of this program. Each local NEP includes participants from all levels of government, interest-group representatives, academia, the business community, and the general public to make decisions about their own estuaries through the development of a comprehensive management plan. A consensus-based process is used to help define each estuary's priority problems and the actions that can be taken to restore and protect the estuary's health. The Comprehensive Conservation and Management Plans (CCMPs) that each local program develops are blueprints for action, focusing on activities that occur within the watershed.

In developing the CCMP for Galveston Bay, Texas, compatible uses of the bay were considered with respect to the natural biological systems. The challenge was to manage human interaction with the bay, including commercial, industrial, agricultural, recreational, and municipal activities, so the long-range value of the resource can be maximized. Conflicting uses of the bay and the problems caused by these conflicts increase the need for comprehensive management. The coordination of scientific and management efforts resulted in a comprehensive plan that meets the environmental and economic needs of the estuary and its inhabitants.

Cooperation by governments and citizens is vital to protecting wildlife and wetland habitat such as this.

Photo Credit
USDA—CS 5884

BUILDING WATERSHED PARTNERSHIPS

Traditional approaches to environmental management have some built-in limitations. For example, jurisdictions built along county and state lines have little relationship to ecological boundaries, making decisionmaking more complex and frustrating. Environmental agencies are often organized along sectoral lines such as air quality and water quality, which promotes decisionmaking in a single sector without consideration of all the sectors at once. Environmental regulators are often criticized for being inflexible, rejecting common-sense solutions that do not easily fit within the regulations. Finally, regulators have been criticized for insufficiently educating and involving the community in decisions that directly affect them.

Both at the federal and state levels, many efforts are underway that attempt to respond to these criticisms.

A key part of any integrated watershed protection effort is to devise an action plan that describes goals, objectives, and a general statement of what the effort hopes to accomplish over a 5- to 10-year period.

When the second Chesapeake Bay Agreement was signed in 1987, it included a clear goal. The goal was to develop, adopt, and begin implementation of a basin wide-strategy to equitably achieve, by the year 2000, at least a 40 percent reduction of nitrogen and phosphorus

entering the main stem of the Chesapeake Bay. The strategy was to be based on agreed-upon 1985 point source loads and on nonpoint loads in an average rainfall year.

The goal is notable for several reasons:

- It is based on a scientific consensus.
- The 40 percent reduction is the key to restoring the Bay ecosystem but is also linked to many other goals.
- It can be easily understood by the public and elected officials.
- It is specific, quantifiable, and can be allocated to particular political jurisdictions or river basins.
- It is fair, yet flexible; each jurisdiction is free to develop its own strategy to meet the goal.
- It has the political support of the Bay States and the EPA as well as the broad support of local governments, the public, and an array of interest groups.

Meeting the 40 percent goal will be accomplished through the implementation of tributary strategies. These are watershed-based plans to reduce nutrient pollution through activities such as wastewater treatment plants, agricultural best management practices, resource protection, and growth management activities.

The emphasis has evolved from an initial focus on the main stem of the Bay to the actions taken by individuals and local governments throughout the watershed. Other goals have been established, including those for acres of submerged aquatic vegetation, number of fish passages, and miles of riparian forest.

Similarly, the National Estuary Program's Comprehensive Conservation and Management Plan for Tampa Bay stresses measurable goals that are realistic and achievable. A key goal of the plan is to cap nitrogen loadings at current levels (the average for the 1992–94 period) to encourage the recovery of sea grasses. Studies indicate that an additional 12,000 acres of sea grass can be recovered by preventing future increases in nitrogen loadings. The Nitrogen Management Consortium, a multi-stakeholder group, is working to identify individual or group projects that would reduce nitrogen loadings by about 11 tons annually, or about two thirds of the total goal. Local governments have agreed to reduce their total load by about 6 tons per year.

Leadership is a second important element of successful watershed protection efforts. Massachusetts, for example, has benefitted from effective leadership at several different levels. Integration between state and local efforts also is key. Besides reorienting their water quality programs to support watershed approaches, the state has reached out to form partnerships with locally based watershed associations. Citizen watershed associations have formed in almost all of Massachusetts' 28 major watershed basins, and more than 500 citizens' groups are active.

Having a coordinator at the watershed level also is desirable. Coordinators can provide a focal point for the watershed effort and help to ensure that someone is paying attention to moving group activities along. The coordinator can play a variety of roles, such as maintaining contact with members of the watershed

groups, serving as liaison with interested parties beyond the groups, calling, facilitating, and summarizing meetings, helping to secure funding and training, and ensuring that watershed plans are developed and implemented.

For example, Mike Morich has been working as coordinator in the Tensas River watershed in Louisiana for over four years. His full-time position is supported by federal agencies (EPA and USDA), The Nature Conservancy, and several foundations. The major issue in the watershed is the severe loss of wetlands. Most remaining wetlands are on privately owned farms, and Mike's background as a lifelong Louisiana resident has helped him build trust with the farming community. He has identified farmers in the watershed who were willing to demonstrate the economic benefits of wetlands restoration and conservation tillage practices, and he works with farmers to point out the economic benefits of management practices such as precision farming and water quality control structures.

Another key element in successful community-based watershed protection efforts is to make sure that the watershed plan is designed at a manageable scale. In the past, many watershed plans were drawn up at too large a scale — 50 square miles or more. The focus of the plans becomes blurred, too many stakeholders get involved, and the responsibility for implementing the plan becomes diffuse. Based on an analysis of first-generation watershed plans, the Center for Watershed Protection recommends that plans be developed around a subwatershed with a drainage area of 2 to 15 square miles. At this scale, mapping, monitoring, and the initial management plan can be completed within a year. The Center also emphasized the importance of having an authority, either at the subwatershed or watershed level, that has the primary responsibility for implementing the plan. Work undertaken at a small scale can be effectively coordinated to meet goals for larger basins, of which the small watershed is a component. The Chesapeake Bay Tributary Strategies and the Great Lakes LAMPs and RAPs mentioned earlier are good examples of this kind of "nesting" of watershed planning.

A recent study of community-based watershed management by the Western Water Policy Review Commission found that these initiatives are widespread and show tremendous variety in structure and function. The review found that a lack of formal authority for the watershed initiative usually does not hinder the effort, and that a reliance on "moral authority" was an important asset. Most initiatives in the West, according to the study, are not closely linked to management programs at the larger river basin scale. The review concluded that the performance of watershed initiatives is "sufficiently positive to merit guarded optimism and to justify greater support from all levels of government."

Water quality issues are a concern to almost all watershed groups. Most of these groups include parties associated with both water and land management. Many federal agencies participate, including the Forest Service, Natural Resources Conservation Service, Environmental Protection Agency, Fish and

Wildlife Service, Corps of Engineers, and the U.S. Geological Survey. Most watershed initiatives are initially highly dependent on federal funds. As programs mature, they may attract additional sources of funding, but even the most successful normally continue to receive some federal support. Participating federal agencies generally provide both direct financial support and in-kind services.

According to the study, a major challenge for these initiatives is to find a focus that is both manageable and sufficiently broad to effectively address watershed issues. Many groups find that field-level activities help retain interest and participation and attract needed resources.

Case Study: San Miguel Watershed Coalition

Located in southwestern Colorado, the roughly million acres that encompass the San Miguel watershed is one of the largest remaining relatively undisturbed areas in North America. The San Miguel River, one of the few remaining free-flowing, ecologically intact rivers in Colorado, extends for about 80 miles from its high alpine headwaters above Telluride to its desert confluence with the Dolores River.

The region's fragile landscapes have come under increasing pressures in recent years, including a five-fold increase in non-skier recreational uses in the past decade and explosive resort and relocation growth. Traditional industries, such as mining, have declined. The region is going through a period of change in both social and economic patterns, including some tensions between the resort interests in the upper basin and ranching communities in the lower basin.

In 1993, Telluride Institute, a nonprofit environmental organization, convened a meeting on sustainable river management that included federal resource managers, elected officials, developers, and others engaged in activities directly affecting the health of the San Miguel River. The group eventually focused on the river-related impacts of summer recreation in the upper reaches of the San Miguel, and decided to hire a river ranger. This group, the San Miguel River Coalition, provided an early foundation for the eventual emergence of a larger coalition.

In the Fall of 1994, the National Park Service's Rivers, Trails, and Conservation Assistance Program (RTCA) was asked to facilitate the development of a management plan for the San Miguel River corridor. RTCA organized an issues workshop with broad participation of interested stakeholders in the region. Following the workshop, it became clear that the most appropriate scale for this effort was the entire watershed, not just the river corridor. Workshop participants generally agreed that broadening the effort to include the entire watershed would bring a greater diversity of perspectives and expertise to the process, could help build a stronger consensus about solutions, and was more likely to succeed. It would also give lower basin communities an opportunity to collaborate with the upper basin in regional decisionmaking.

The interest in developing a watershed approach drew broad support, helped by federal policy shifts towards ecosystem

management as well as local concerns over the region's rapid growth and resulting environmental degradation.

Facilitated by RTCA and the Telluride Institute, and with strong support from the Bureau of Land Management, the San Miguel Watershed Coalition was formed. The group developed a community-based concept of how to conduct a watershed planning effort, attaching particular importance to citizen involvement and responsiveness to local concerns. Workshops and focus groups identified five general issues: water, natural resources, recreation, education, and community growth and preservation.

With the information developed in the workshops and focus groups, a planning team began to reshape the information into a planning document. The first draft of the plan was completed in June 1997.

The Coalition plan included a vision of the future built upon five elements:

- A landscape maintained in good health through protection and responsible use of natural resources.
- Availability of a diversity of high quality recreational opportunities.
- A sustainable economy offering opportunities for growth and development guided by a strong sense of community identity.
- A cooperative atmosphere where agencies, organizations, and individuals collaborate on management decisions with an ecosystem mindset.
- A citizenry educated about the close connection between resource conservation, economic vitality, and quality of life and committed to good watershed stewardship.

In the discussion on water, the plan identified a variety of issues. These include the reduction of instream flows and lake levels due to increasing water demands and consequent effects on the natural values of streams and lakes; depletion of groundwater resources; inadequate water conservation efforts; limitations on water available to the towns of Nucla, Norwood, Naturita, and Telluride; increasing threats to water resources on public lands; impacts to water users from bypass flows required by the Forest Service; impacts of planned and existing water developments; and increasing levels of pollutants, including sediment, biological pathogens, nutrients, urban runoff, heavy metals, and hazardous materials.

The plan includes six basic recommendations for water, including actions that would help meet each recommendation. The first objective is to "manage groundwater and surface water sources for a sustained high quality water supply." To meet this objective, promising actions include: developing a water budget that quantifies historic and future water uses in relation to measured supply of ground water and surface water; exploring opportunities to coordinate diversions and releases in order to minimize impacts on downstream riparian ecosystems; exploring opportunities for receiving or acquiring water from private entities for public benefit; instituting a surface water and wellhead protection program coordinated with the county; upgrading rural water

systems to accommodate future development, determining appropriate protection levels of the watershed to guide future growth plans, improving collaboration and consensus among water interests, and developing a fact sheet on groundwater supply and limitations for public distribution.

The plan's other water-related potential actions include: conducting a comprehensive instream flow assessment; determining the water needs for public land management; developing and implementing a water conservation plan for the basin; metering all municipal water use and charging fees based on volume used; and developing and implementing a stormwater management plan covering developed recreation areas, highways, and municipalities.

Though only a few years old, the Coalition has succeeded in raising more than $200,000 in grants and $350,000 in in-kind services. The lion's share of the grant money came from several Environmental Protection Agency sources, and benefitted from a shift in focus at EPA to community-based ecosystem protection.

Yet to be resolved is the best permanent organizational structure to guide the watershed project, manage funds, and effectively involve public citizens.

LEARNING ABOUT WATERSHEDS

Powerful new tools such as Internet sites and geographic information systems are increasingly available to support watershed groups.

At the University of Connecticut Cooperative Extension, the Nonpoint Education for Municipal Officials (NEMO) project uses Geographic Information Systems (GIS) and remote sensing for watershed analysis. GIS maps can help educate local land use decision makers on the complexities of the land use-water quality connection. The maps are useful ways to illustrate the concept of watersheds, the role of land use in determining the health of watersheds, the relationship between watershed boundaries and political jurisdictions, and the location of key natural resources.

NEMO is particularly valuable in assessing trends in the extent of impervious surfaces, such as parking lots, which are a key indicator of watershed health. Project staff can develop a "build-out" analysis that looks at trends based on local zoning regulations. The analysis can help local officials think about current land use plans and ways to adjust plans to help protect water resources.

Save Our Streams, which operates out of Gaithersburg, Md., uses workshops, guides, and a 1-800 number to provide technical assistance on stream restoration and volunteer monitoring techniques for local watershed groups. With a database of over 4,000 projects, Save Our Streams can often refer callers to other projects across the nation who have tackled and solved similar watershed problems.

SOS encourages local groups to partner with federal and state agencies and private sector sponsors to bring costs down. Some groups can get enough outside funding to restore a stream with as little as $1,000 of their own money.

Know Your Watershed, a public-private partnership based in West Lafayette, Indiana, supports existing watershed partnerships and helps in the creation of new ones. The organization's goal is to have 2,000 watershed partnerships in the country by the year 2000; as of mid-1997, it had identified over 1,000. Know Your Watershed supports watershed-to-watershed networking, technology transfer efforts, and capacity building at the regional, state, and local levels. Another emerging and well-organized group is River Network.

Databases and modeling tools also are widely available. EPA sponsors Surf Your Watershed, an internet tool for managers and citizens to locate watershed information. In partnership with others, EPA also manages an Index of Watershed Indicators, which describes the condition of and threats to watersheds nationally, drawing upon data provided by states, tribes, several federal agencies (NOAA, NRCS, and the Corps of Engineers), and The Nature Conservancy.

STATE-BASED WATERSHED PROGRAMS

Several states are undertaking a large-scale revamping of their approach to environmental management.

Florida, for example, is emphasizing both management changes and the cultural changes needed in government institutions and the public to achieve ecosystem management. Wisconsin is reorganizing its management structure and approach to better fit existing ecosystems and watersheds. North Carolina is changing its approach to water quality planning, to emphasize assessing an entire river basin at one time.

Florida

In Florida, the Department of Environmental Protection is creating a management framework based on Ecosystem Management Areas (EMAs). These areas, which are often based on drainage or watershed boundaries, are large enough to effectively address major hydrological and ecological connections. The state is assembling management teams for each EMA and technical advisory committees to support the EMA teams' decisionmaking.

State officials recognize that success requires a cultural change on the part of both the agency and the public. At the agency level, the changes include retraining to promote a results-oriented philosophy, developing a common-sense process, moving away from a philosophy based on reaction, reorganizing programs away from a concentration on a single media, facilitating cooperative and voluntary solutions to issues between the agency and private landowners, reallocating agency staff and budgets to support EMAs, incorporating ecosystem management principles into the department's programs, rules, and policies, and shifting program emphasis from pollution control to pollution prevention.

Another goal is to develop a public ethic of shared responsibility for the environment. The state is implementing a private lands initiative to foster stewardship on privately owned lands and has created

an awards program to recognize outstanding ecosystem management programs.

Another goal of the reorganization effort is "common-sense regulation." Common-sense regulation recognizes that each circumstance, each application, and each site is different. It looks for solutions that are based on consensus; based on pollution prevention, rather than end-of-pipe control; flexible, rather than rigid; and able to provide economic incentives to applicants.

The state is not replacing the current permitting program, but is proposing a new, voluntary, parallel permitting and approval process that will provide meaningful economic and regulatory incentives to applicants in return for better protection of ecosystems. Multidisciplinary teams from the department and other agencies will review all aspects—air, water, wildlife, land use, and other—of an application. Teams will include local, regional, state, and federal representatives, and will be open to interested third parties.

Finally, the department is continuing to develop alternative approaches to its enforcement program, encouraging programs such as no-penalty self-audits and the development of cooperative relationships with regulated interests. These actions are intended to supplement, not replace, traditional enforcement activities.

One component of Florida's program is based upon EPA's audit policy, which encourages regulated entities to voluntarily discover, disclose, and correct

Rivers are often boundaries as well as resources. Great Falls on the Potomac River is valued by people of many states and communities.

Photo Credit
Greg Baier USGS

violations of environmental requirements. Incentives include eliminating or substantially reducing the gravity component of civil penalties and not recommending cases for criminal prosecution where specified conditions are met, for those who voluntarily self-disclose and promptly correct violations. The self-audit policy is one of a suite of incentives and compliance assistance activities Florida is using to supplement traditional enforcement and encourage voluntary compliance.

A second, newly developed component of Florida's program is the development of a four-tiered measurement system to evaluate the results of the agency's compliance and enforcement efforts. Tier 1 measures environmental results—things like improvements in air and water quality. Tier 2 measures cultural changes such as improvements in compliance rates, voluntary pollution prevention and use of improved technology—things indicating acceptance of responsibility for the environment by the regulated community. Tier 3 measures agency activities such as permits issued or denied, compliance inspections, enforcement actions, compliance assistance and public outreach—indicators of how much effort the agency is putting into various compliance and enforcement strategies. Tier 4 provides budget information to show the links between dollars spent and what the agency has accomplished. This data is updated in a quarterly report, which is made available to the public in both hard copy and on the Internet.

Lastly, Florida has adopted an environmental problem solving (EPS) methodology. EPS is a six-step process designed to identify important problems, design measurements to assess the impacts of those problems, develop solutions, and finally, using the measurement system, evaluate the effect of the management response.

In sum, the Florida effort is endeavoring to make citizens full partners in environmental protection, substitute cooperative problem solving for antagonistic legal wrangling, inject common sense into the regulatory process, develop enforcement alternatives and effectiveness measurements, require management based on ecological rather than administrative or political boundaries, and integrate efforts that were previously segregated by agency, program, or media.

Wisconsin

A similar effort is underway in Wisconsin. Like Florida, the changes underway in Wisconsin represent a response to key changes in understanding and approach to natural resources management. For example, officials at the State's Department of Natural Resources found that large businesses such as paper manufacturers had learned that eliminating pollution voluntarily cost less than complying with ever-stricter rules, and that the state needed to encourage these efforts with incentives rather than new regulations. A second new understanding was that people and communities wanted to solve local environmental problems, but preferred locally applied expertise and support to state mandates and rules. The Department also grasped that the science driving our understanding of natural resources was increasingly focusing on

the interdisciplinary study of interactions within an ecosystem, and that the public wanted less government but still valued a clean environment.

The Department is reorganizing to bring its institutional structure closer to the current realities of environmental protection. At the central office in Madison, a new six-division structure has fewer staff and supervisory layers and is intended to provide policy and other essential support for field operations. For example, the new water division consolidates five programs formerly located in three separate divisions, bringing together fisheries management and shoreline/wetland protection programs with water quality improvement programs.

The Department is replacing its old six-district field structure with five regions that are roughly aligned with natural ecological features. The Northern Region, for example, covers northern Wisconsin's forest and lake belt, while the new Northeastern Region encompasses the Fox-Wolf River basin.

Each of the five regions is divided into four to six geographic management units with boundaries based largely on major river basins. Most department staff are assigned to these units. The new structure emphasizes a team approach that brings together employees with different types of expertise who can collectively develop an interdisciplinary perspective on environmental issues. The team concept also is designed to encourage a higher level of community cooperation and citizen involvement.

For example, a river basin team might include an aquatic biologist, wastewater engineer, shoreline/wetland specialist, safe drinking-water engineer, fishery manager, and water resource planner. The team also could include representatives from civic groups, conservation clubs, environmental groups, business and industry, other government agencies, agriculture, and education. The team could be asked to assess the quality of water, fisheries and aquatic resources in a river basin; analyze and identify problems affecting water quality, aquatic life, and water uses; involve citizens in setting river basin goals and priorities and in finding and choosing solutions to problems; and regularly report progress toward goals and applaud partner successes.

Though initiated by the state, geographic management units are intended to address the mutal needs of all partners. State officials see their role as bringing regional and national perspectives to the discussions as well as an integrated, ecosystem view of the issues and trade-offs.

North Carolina

In North Carolina, population growth and development pressures—including changes in land use and the emergence of nonpoint sources as a significant cause of water pollution—pose a variety of critical water quality management issues. The issues include:

- How much waste assimilative capacity is left within the state's major receiving waters for new and expanding discharges?

- What should be done where capacity has been exhausted?
- Where capacity exists, how much should be set aside for new and expanding discharges?
- What impact will these decisions have on municipal growth and industrial development?
- Which waters warrant special consideration for protection of critical habitat or high quality values?
- Which waters are impaired, what are the causes and sources of impairment, and how can quality be restored?
- What is the relative contribution of nonpoint source loading to water quality problems and to what extent will it affect future point source allocations?
- How can amounts and sources of nonpoint source loadings be accurately determined?
- What opportunities are there to significantly reduce nonpoint source pollution?

North Carolina state officials found that traditional approaches to evaluating pollution discharge permits on a case-by-case basis did not adequately deal with these issues. A new approach was needed that would address the interactive and cumulative water quality impacts from multiple dischargers and nonpoint sources.

State officials decided that the best way to address these issues was to simultaneously assess water quality and aquatic resources throughout an entire river basin, and to use that information to guide subsequent decisions about discharge permitting, wasteload modeling and nonpoint source pollution control.

The state Division of Water Quality is preparing basinwide plans for each of the state's 17 major river basins. The first round of plans is to be completed by August 1998, with each plan to be updated at five-year intervals. The first basinwide plan, for the Neuse River, was completed in 1993.

The state's basinwide approach provides a number of benefits. For example, evaluating an entire river system at the same time, rather than stream fragments or individual facilities, encourages managers to consider water quality problems where the problems are far removed from the source or where downstream impacts are caused by the cumulative effects of point and nonpoint sources.

The approach enables managers to issue permits for all dischargers in a basin at the same time. Under the old system, permits were reissued randomly across the state as they came up for renewal. Beginning with the Neuse River in 1993, all discharge permits for each basin are now scheduled to expire and be renewed in the same year. They will be reviewed and reissued at five-year intervals thereafter.

Basinwide management also better enables state officials to grapple with the relative contributions of point and nonpoint source pollution in a river basin. The state is using the total maximum daily load (TMDL) approach, as mandated by the Clean Water Act, to determine the total pollution loading that a water

body can assimilate while still maintaining its water quality classification and standards. Though technically difficult, the approach is useful for developing point source control strategies and targeting areas for nonpoint source management. Once a TMDL has been established for a river basin, or for certain waterbodies within the basin, point and nonpoint source control strategies can be developed to prevent overloading of the receiving waters, allow for a reasonable margin of safety, and optimize assimilative capacity.

The state's basinwide approach is intended to evolve over time, and can be used to help predict the long-range consequences of growth and development on water quality and develop long-range protection strategies. With more lead time and involvement in the planning process, local governments, industry, and others can better plan their activities to work in consonance with these strategies.

Another important development affecting the state's approach is the recent outbreaks of toxic *Pfiesteria* in tributaries of the Albemarle-Pamlico sounds, which are contributing to rising public anxiety about the safety of North Carolina's seafood in general and adversely affecting the state's seafood sales.

North Carolina's fisheries are overwhelmingly estuarine-dependent. Species must utilize estuaries to complete their life-cycle – spawning, nursery areas, feeding areas, and migration routes. The state ranks among the top 10 states in the nation in both commercial and recreational landings, which contribute more than $1 billion annually to the state's economy.

To address these public concerns, as well as to clean up North Carolina's waters to reduce or prevent future *Pfiesteria* outbreaks, the state is monitoring, evaluating and classifying more than 2.1 million acres of coastal waters to determine their safety for shellfish harvesting and consumption, and initiating a recreational water quality monitoring program to help allay mounting concerns about the safety of North Carolina waters for fishing, swimming, boating and other water-based activities.

The state also recognizes that too many nutrients (phosphorous and nitrogen) are getting into North Carolina waters and causing fish kills, algal blooms and degradation of waterways and estuaries. To address these problems, the state has:

- Passed the Clean Water Responsibility Act, a far-reaching, progressive and aggressive environmental law, which puts a two-year moratorium on hog farms in the state, reduces nutrient limits for wastewater dischargers and nonpoint sources and includes provisions for improved land-use management.
- Established a scientific advisory council on water resources and coastal fisheries management.
- Developed a strategy to reduce nutrients in the troubled Neuse River and continue basinwide planning efforts to address water quality concerns.

- Established a clean water management trust fund, which provides tens of millions of dollars each year to water quality protection initiatives.
- Established a wetlands restoration program.
- Toughened enforcement policies.
- Strengthened sedimentation and erosion control programs.
- Established a rapid response team to investigate fish kills in the Neuse River and expanded the coastal recreational water quality testing program to protect public health.
- Toughened siting, permitting and operating requirements for intensive livestock operations.
- Increased funding to the state agricultural cost share program, which assists farmers in controlling run-off from crops, fields and feedlots.
- Established a medical team to examine the health effects of *Pfiesteria* and a hotline for citizens to call for assistance.
- Stepped up environmental education efforts to inform citizens as to how their activities affect their river basins.

NEW STRATEGIES: WATERSHED-BASED TRADING

Watershed-based trading is an innovative way for stakeholders — including state and local governments, point source dischargers, contributors to nonpoint source pollution, citizen groups, other federal agencies, and the public at large — to develop common sense, cost-effective solutions to water quality problems in their watersheds.

Trading can be an efficient, market-driven approach to meet the goals of the Clean Water Act. It can also provide substantial new flexibility for watershed managers. For example, it provides an opportunity to:

- Facilitate nonpoint source reductions where they otherwise might not occur.
- Meet the designated uses of a waterbody at a lower cost, or expand a waterbody's designated uses at the same cost.
- Allow an existing or new source to add new pollution to a waterbody, which would be offset by pollution reductions elsewhere in the waterbody.
- Accelerate the implementation of pollution control measures.

Trading generally takes the form of an agreement between two or more parties within a waterbody that alters the allocation of pollution reduction responsibilities among the parties. A "buyer" and "seller" agree to a trade in which the buyer compensates the seller to reduce pollutant loads. Buyers purchase pollutant reductions at a lower cost than what they would spend to achieve the reductions themselves. Sellers provide pollutant reductions and may receive compensation.

There are five general categories of watershed-based trading:

- Point/Point Source — a point source arranges for another point source to undertake greater-than-required reductions (beyond the minimum technology-based standards) in pollutant discharges in lieu of reducing its own discharge level.

- Intra-plant — a point source allocates pollutant discharges among its outfalls in a cost-effective manner, so long as the combined discharge is the same or less and each outfall complies with requirements to meet water quality standards without trading.

- Pretreatment — an industrial source that discharges to a treatment plant arranges for greater-than-required reductions in pollutant discharge (beyond the minimum technology-based discharge standards) by other indirect sources in lieu of upgrading its own pretreatment.

- Point/Nonpoint — a point source arranges for control of pollutants from nonpoint sources to undertake greater-than-required pollutant reductions (beyond the minimum technology-based discharge standards) in lieu of upgrading its own equipment.

- Nonpoint/Nonpoint — a nonpoint source arranges for more cost-effective control of other nonpoint sources in lieu of installing or upgrading its own controls.

These arrangements can vary in complexity and form and potentially include many parties. Hypothetically, for example, a food processor facing new pollutant reduction requirements (the buyer) could contract directly with another processor (the seller) to install additional control devices to reduce the seller's pollutant loads. The seller would maintain its own controls to achieve the required load reductions plus an additional load reduction credited to the buyer. The trade is incorporated into the NPDES permit and is approved by the permitting authority.

In another case, a nonpoint source tree farming operation purchases "water quality improvement shares" from a nonprofit environmental organization. The organization uses the proceeds from the sale of shares to conduct stream and habitat restoration projects, which provide water quality improvements. The tree farmers receive pollution reduction credits proportionate to their funding contribution to the water quality improvements.

In a real-life example, selected publicly owned treatment works in North Carolina's Tar-Pamlico Basin pay into a state fund that supports implementation of best management practices on farms. The treatment plants achieve water quality goals less expensively than if each plant upgraded its facility independently. Trading in the Tar-Pamlico Basin is described in more detail in Chapter Six.

In addition to the cost savings, trading can provide environmental benefits above and beyond those required by law. For example, the State of Maryland accepts fee-based compensation for mitigation requirements if it determines that creation, restoration, and enhancement of small nontidal wetlands is not feasible.

Fees are deposited into a trust fund that pays for larger restoration projects. The state believes consolidating small and isolated restoration project costs to fund larger ones is a more environmentally effective approach to mitigation and water quality protection.

Making pollution reductions more affordable means sources can be reduced more quickly or in greater amounts. In addition, cost savings can be used for other purposes, such as additional resource protection activities or community services such as education. Trading can also keep consumer costs down as industry and business save.

In New Jersey, the Environmental Protection Agency and the State Department of Environmental Protection are working with stakeholders to develop a trading mechanism, as a means for companies to meet new local limits for their metals discharges into publicly owned treatment works (POTWs). Companies that have met their basic technology-based requirements can use trading to help them meet additional locally imposed limits on pollutants.

When controls for metals are instituted, facility managers often find they can reduce the levels of metals in effluent more than is required. Trading allows facilities in the same POTW service area to work together to achieve discharge reductions at a lower cost. A company with new controls that lower metals discharges below required levels could "sell" its excess reductions. A buying company and a selling company negotiate a price for the metals credits. The permits of the trading partners are then adjusted to reflect the amount of credits sold in the trade.

The pilot team is working with the Passaic Valley Sewerage Commissioners in Newark and its industrial permittees to facilitate a trade on local limits of metals. So far, two companies have negotiated a trade, signed a contract, and their permits have been adjusted to reflect the trade by Passaic Valley. Additional companies have expressed interest in trading and may negotiate trades in the future to help meet their metals discharge requirements.

The pilot team will document the benefits and challenges of the trade and then explore the applicability of trading to other pollutants and other POTWs.

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CHAPTER THREE

Headwaters

Headwaters — defined simply as the source, or upper part, of a stream — are traditionally visualized as pristine, remote, free-flowing streams, unpolluted and relatively unaffected by human activities.

In some parts of the country, that vision still bears some connection to reality. Embarking on a 540-mile trip down the entire length of the Chattahoochee River in Georgia, Joe and Monica Cook wrote in the *Georgia Journal*:

"We began our journey the day before on a sub-freezing morning in Chattahoochee Gap, 3,500 feet above sea level, where the river oozes to life from a spring surrounded by huge poplars and occupied by salamanders. The mountain's early spring fireworks — bloodroots and violets — brightened our path, but it took us six hours to travel less than four miles. Now the river's cascades and falls are frequent and growing in size, the banks of the gorge steeper and more crowded with underbrush.

"Above the roar of the water, we hear the voices of fishermen, and I scramble down to their spot and ask them if they know the river's course for the next few miles.

"One, wearing an Atlanta Braves cap and casting with a spinning reel at the clear water, turns, bewildered. 'I went in there once,' he said, pointing to the deepening gorge. 'Fell on a rock and busted my knee cap. It took me seven hours to get out to a hospital. I can give you a ride to the other side. The truck's just at the top of the hill.'

"'No thanks,' I said, still determined to beat our way through. 'We'd rather walk.'

"Our trout fisherman friend was right. Shortly after leaving his spot, we ran into a nearly impassable wilderness — a crunch of wild water and mazes of rhododendron thickets and dog hobble, a low-growing shrub so named because dogs are likely to get tangled in it. So are people. Rhododendron thickets are often referred to as 'hells.' We now knew why. They are hell to travel through. We abandoned our plan to follow the river itself, opting to follow the U.S. Forest Service road running along high ground above the gorge. That three-mile stretch of water is the only part of the river we haven't seen."

With the exception of Alaska, however, civilization is usually not far from even the wildest headwaters. Just a few miles downriver, the Cooks arrived in Helen, a booming lumbering town from 1910 to 1940. Helen became a ghost town after the timber was exhausted, but has since revived as an "alpine village" that attracts some three million tourists annually.

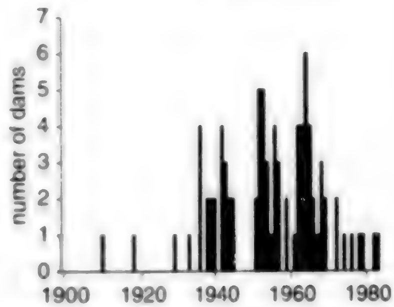
Box 3.1
Dams and Dam Construction

There are now more than 75,000 dams higher than 6 feet in the United States, both in the upper and lower reaches of rivers. The reservoirs behind these dams cover about 3 percent of the nation's land surface. In a given year, 60 percent of the United States' entire river flow can be stored behind reservoirs.

Most of this construction occurred between the 1930s and 1960s (Box Figure 3.1). Between 1935 and 1985, over 600 federally funded flood-control projects were built.

Only 2.7 percent of the nation's dams are owned by the federal government. The Corps of Engineers manages 555 dams. The Interior Department's Bureau of Reclamation manages 348 dams with a total storage capacity of 245 million acre-feet of water (an acre-foot is equivalent to 325,851 gallons of water).

Box Figure 3.1 Dates of Closure of U.S. Dams with Reservoir Capacity of a Million Acre-feet or More, 1900-1983

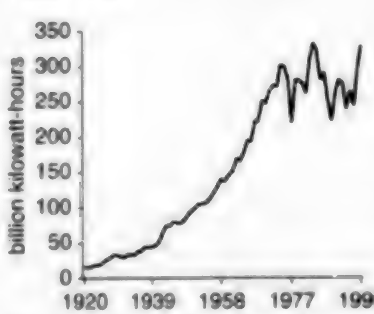


Source: Graf, W.L., "Landscapes, commodities and ecosystems -- The relationship between policy and science for American rivers," in Water Science and Technology Board, *Sustaining Our Water Resources* (National Academy Press, Washington, DC, 1993).
Note: Data are for the contiguous United States.

Like the Cooks, many Americans are drawn to the nation's untamed rivers and landscapes. For Norman Maclean's fictional Montana family in *A River Runs Through It*, "there was no clear line between religion and fly fishing." And for many other Americans, the river experience is an essential part of the human experience. Americans increasingly are visiting the nation's great rivers and landscapes; since 1980, for example, visits to the National Park System are up nearly 40 percent.

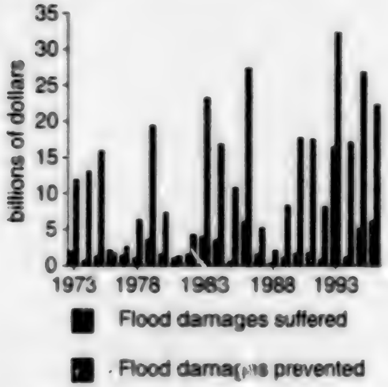
Aside from tourism and outdoor recreation, many other activities occur in headwaters areas, notably logging, min-

Figure 3.1 U.S. Conventional Hydroelectric Power Generation, 1920-1996



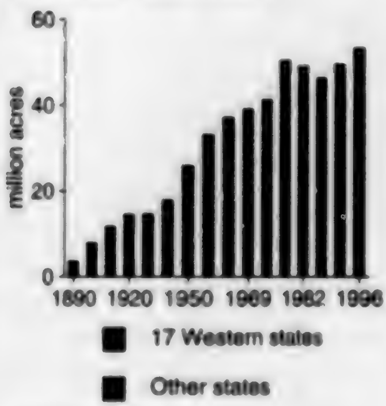
Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1996* (DOE, EIA, Washington, DC, 1997) and earlier reports.
Note: Excludes pumped storage facility production.

Figure 3.2 U.S. Flood Damages Suffered and Prevented, 1973-1996



Source: U.S. Army Corps of Engineers, *Annual Flood Damage Report to Congress for Fiscal Year 1996* (USACE, Washington, DC, 1997) and earlier reports.

Figure 3.3 U.S. Irrigated Farmland, 1890-1996



Source: See Part III, Table 7.11.
Note: 1890-1992 data are for years coinciding with the Census of Agriculture; 1996 data are estimates.

ing, and farming. In addition, it is usually in the upper reaches that most rivers begin to lose their natural character.

TAMING THE RIVER

The age of the free-flowing river is largely over in the lower 48 states, with virtually every river regulated by dams, locks, or diversions (Box 3.1).

There are a host of reasons to build dams. They provide water for cities, farms, and industries; help control floods and manage flow; improve navigation; generate electrical power; and provide opportunities for recreation. In 1996, for example, hydroelectric power generated 329 billion kilowatt-hours of electricity, or 11% of U.S. electricity generation (Figure 3.1). Hydroelectric powerplants in the Columbia River and its tributaries produce 75 percent of the Pacific Northwest's electricity.

Dams have improved the dependability of water supplies, particularly for arid and semiarid regions. In many instances, dams have reduced the risk of catastrophic floods (Figure 3.2). Since dams were built across rivers in the Connecticut River Valley, no floods have occurred like the ones that crippled the towns of Bolton and Hartford in 1927 and 1936. But, as evidenced by the destructive floods of recent years, dams have not completely eliminated the risk of major floods.

Water diversions have also played an important role in the nation's agricultural development. Each year, for example, 8.2 million acre-feet of water are diverted from the lower Colorado to homes and farms in California and Arizona through aqueducts that cross hundreds of miles of intervening desert. None of this water reaches the Gulf of California. By 1996,

Aerial View of the Snake River

Photo Credit
USDA—94CS3964

some 42.2 million acres in 17 Western states were irrigated, with another 11.1 million irrigated acres in the rest of the nation (Figure 3.3).

As dams became bigger and more expensive, more potential benefits were needed to justify the costs of dam construction. The Glen Canyon Dam in Arizona was initially conceived as a project to balance the water allocations between the upper and lower basin states of the Colorado River. To justify the initial price tag of $325 million, additional benefits such as water conservation, downstream distribution, and hydroelectric power (and subsequently recreation and flood control) were added to the dam's operating criteria.

Dams and the Environment

Dams have a variety of environmental impacts. The process of dam construction and subsequent impoundment of waters results in the loss of riparian areas, wetlands, and upstream forestlands. The river emerging from a dam is not the same river entering its reservoir. Its daily discharge may vary wildly and be hotter or colder. Its seasonal pattern of high spring floods and low winter flow may be severely inhibited. The sediment-free waters may scour the downstream bed and banks or rob lower reaches of needed replenishment. A completely new succession of riparian plants and animals may move into the river and valley below the dam. Fish migrations are blocked or

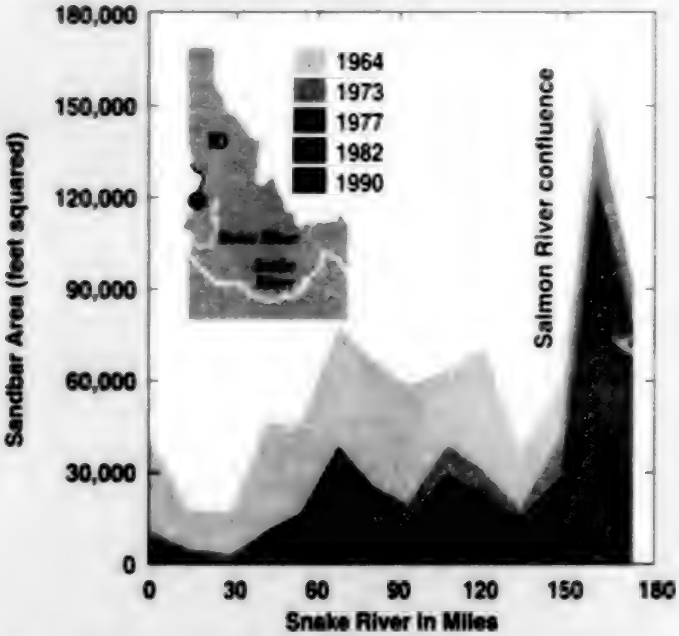
Figure 3.4 The Snake River in Oregon, Idaho, and Washington

Source: Collier, M., R.H. Webb, and J.C. Schmidt, *Dams and Rivers: A Primer on the Downstream Effects of Dams*, USGS Circular 1126 (USGS, Tucson, AZ, 1996).

severely disrupted. Native fishes may die or be severely stressed. Water quality may be improved or impaired.

A recent report by the U.S. Geological Survey, *Dams and Rivers: Primer on the Downstream Effects of Dams*, looks at several regulated rivers, including the Snake, Chattahoochee, Platte, Green, and Colorado rivers. Each of these rivers highlights a particular use of a dam or a particular downstream effect.

Figure 3.5 Sandbars on the Snake River in Hells Canyon



Source: Collier, M., R.H. Webb, and J.C. Schmidt, *Dams and Rivers: A Primer on the Downstream Effects of Dams*, USGS Circular 1126 (USGS, Tucson, AZ, 1996).

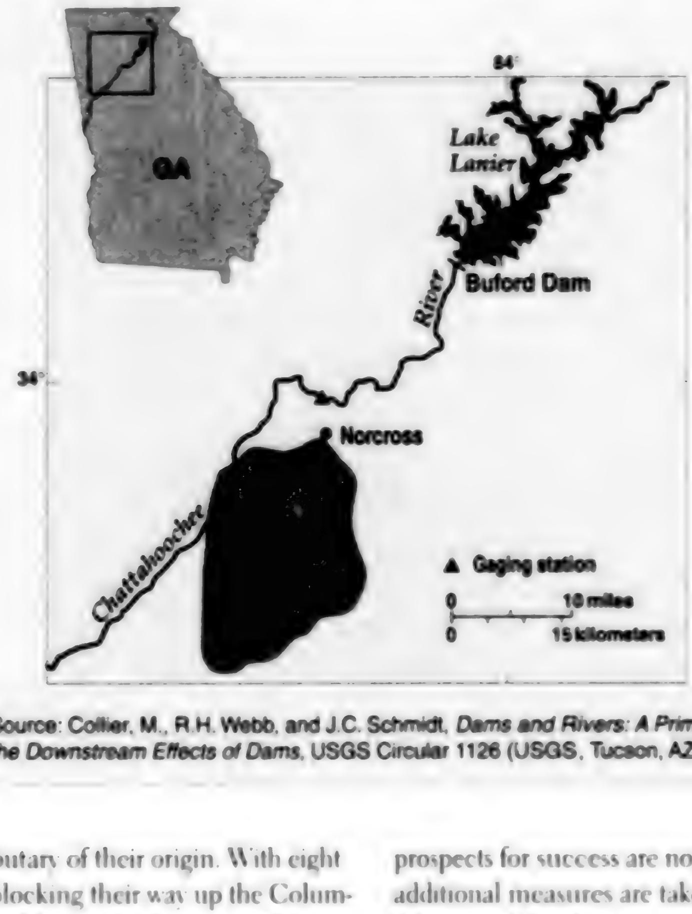
Snake River. The Snake River in Oregon, Idaho, and Washington, is the most extensively dammed river in the West (Figure 3.4). The generation of hydroelectic power has severely changed the normal dynamics of the river's flows. Dams on the Snake block historic salmon migratory runs, and frequent high releases have caused depletion of sand downstream from the dams.

The Idaho Power Company uses coal-fired generating stations to provide base-load power, but obtains all of its peak power from the dams of the Hells Canyon Complex. The company waits to release water until demand is high.

The three dams of the Hells Canyon Complex are very effective sediment traps; the water emerging from Hells Canyon Dam is usually crystal clear. Prior to construction, the waters of the Snake below its confluence with the Salmon carried as much as 5 million tons of sediment downstream. But water clarity comes with a price. Since dam construction, the surface area of the beaches below Hells Canyon have shrunk by 75 percent (Figure 3.5).

Prior to dam construction, chinook and sockeye salmon would migrate up from the Pacific Ocean through the Columbia and Snake rivers to spawn in

Figure 3.6 The Chattahoochee River in North-Central Georgia



Source: Collier, M., R.H. Webb, and J.C. Schmidt, *Dams and Rivers: A Primer on the Downstream Effects of Dams*, USGS Circular 1126 (USGS, Tucson, AZ, 1996).

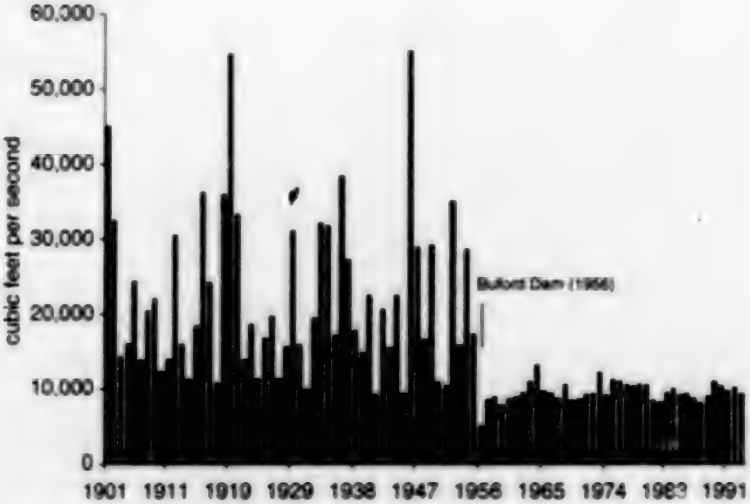
the tributary of their origin. With eight dams blocking their way up the Columbia, roughly one third or more of the total spawning population is lost. When spawning is successful, the young fish have even lower rates of success in migrating downstream. The chinook is a threatened species; the sockeye is considered endangered.

The Idaho Power Company built fish ladders and other bypass systems into each of the Hells Canyon dams, but all were unsuccessful. Today, no salmon migrate above Hells Canyon. The company also has funded fish hatcheries, but prospects for success are not bright unless additional measures are taken to move fish around the dams.

Chattahoochee River. At regular intervals, the Chattahoochee River in north-central Georgia used to rise over its banks in massive floods, carrying mud and sand across nearby farmlands (Figure 3.6). All that stopped in 1956, when the Corps of Engineers completed the $45-million Buford Dam and Lake Sidney Lanier began to fill in behind the dam.

Buford Dam has admirably fulfilled its role in controlling floods; since 1956, no destructive floods have occurred on the

Figure 3.7 Peak Flow Rates for the Chattahoochee River, 1901-1994



Source: U.S. Department of the Interior, U.S. Geological Survey, National Water Data Storage and Retrieval System (USGS, WATSTORE, Reston, VA, 1997)

Chattahoochee below Buford (Figure 3.7). The river is also the most important source of drinking water for millions of people in the Atlanta metropolitan area downstream.

The river and Lake Lanier are enormously popular with area residents. In 1990, 19 million people came to Lake Lanier, making it the most visited federally managed reservoir in the country. In 1978 Congress authorized the Chattahoochee River National Recreation Area, comprised of 14 scattered units between Buford Dam and Atlanta. The river is heavily used for fishing, canoeing, biking, picnicking, jogging, and swimming. Recreation, water quality, and fish and wildlife concerns have become important priorities in the management of the dam.

The river's double role as a source of both recreation and power poses some challenges for the river's managers. A reduction in extreme fluctuations would increase recreational safety by reducing the risk that sudden fluctuations would endanger unsuspecting fishermen, but it would diminish the dam's power generation capabilities. Dam releases could be designed to minimize downstream erosion, but power generation would suffer.

Platte River. Along the Platte River in Wyoming, Colorado, and Nebraska, some half a million sandhill cranes return to roost every February and March, seeking the river's shallow waters broken up by sand spits and islands (Figure 3.8). During the day, the birds fly a few miles to nearby cornfields that have

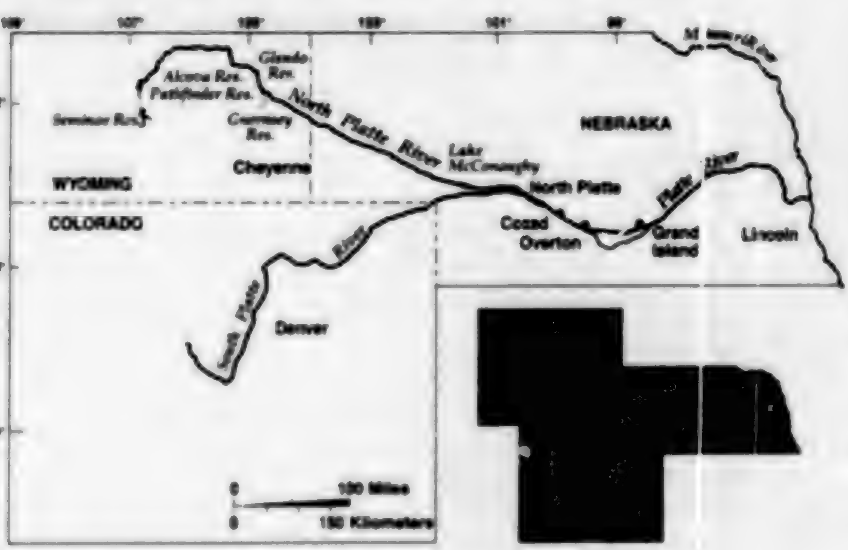
been dormant since the previous fall's harvest. During their six-to-eight week stay on the Platte, the birds can add 15 percent or more to their wintertime body weight.

The Platte has changed substantially since the early Westward expansion. By 1885, more water had been appropriated by canal builders and farmers than actually flowed in the South Platte during the summer irrigating season. By 1917, the entire North Platte was over-appropriated during the summer months.

Dam-building began in earnest with the passage of the Reclamation Act of 1902. Six major dams storing nearly 5 million acre-feet of water were built across the North Platte, while the South Platte's dams could hold back 1.3 million acre-feet. Increased supplies of water created a new wave of canal building along the North Platte until the 1930s; after that, farmers turned to groundwater for additional irrigation. By the 1980s, annual river flows were only about one third the pre-dam average (Figure 3.9).

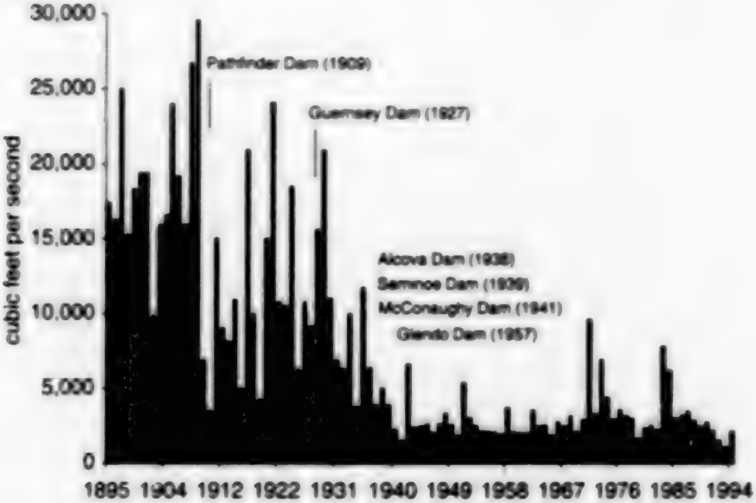
The steady reductions of both peak springtime and total annual flows have taken a toll. In the absence of floods, cottonwoods, elm, and willow successfully invaded the bare sandbars. By 1965, the 60-mile channel above Overton was only 10-20 percent of the width measured in 1865. The cranes have abandoned a bit more habitat every year, leading to increased crowding on the remaining habitat and a greater risk of avian disease outbreaks.

Figure 3.8 The Platte River in Wyoming, Colorado, and Nebraska



Source: Collier, M., R.H. Webb, and J.C. Schmidt. *Dams and Rivers: A Primer on the Downstream Effects of Dams.* USGS Circular 1126 (USGS, Tucson, AZ. 1996).

Figure 3.9 Peak Flow Rates for the North Platte River, 1895-1994



Source: U.S. Department of the Interior, U.S. Geological Survey, National Water Data Storage and Retrieval System (USGS, WATSTORE, Reston, VA, 1997).

Hydrologists are contemplating dam releases that would open and maintain a channel adequate for the cranes, but that could mean less irrigation water for farmers upstream. Conceivably the timing of releases might be planned for periods when farmers do not need water, or farmers could switch to crops that require less water. In any event, the tradeoffs between farm productivity and crane habitat are not easy.

In mid-1997, after three years of negotiations, the Department of Interior and the states of Colorado, Nebraska, and Wyoming signed a cooperative agreement for a federal/state recovery program for whooping cranes and other endangered species along the river. The agreement provides for:

- Initiation of a basin-wide environmental study of the Platte.
- A basin-wide analysis of opportunities for water conservation and enhanced water supply.
- More effective habitat improvements based on basin-wide factors.
- Greater regulatory certainty for individual projects throughout the basin.
- Commitments to seek immediate funding for habitat activities.
- Permanent restoration and protection of 29,000 acres of habitat.
- Adjustment of Kingsley Dam operations to provide enhanced flows for fish and wildlife on the Central Platte.

- Simplification of the Endangered Species Act review process for individual water-related actions.
- Development of legal and institutional protections to help ensure that existing flows and any new water deliveries will reach the critical habitat areas.
- A means to ensure that each party contributes its fair share towards the program's goals.

Green River. Some 45,000 square miles in Utah, Colorado, and Wyoming contributes runoff to the Green River, a spectacular landscape that includes Dinosaur National Monument, Canyonlands National Park, and Glen Canyon National Recreation Area. The river's source in Wyoming's Wind River Range is 730 miles upstream from its confluence with the Colorado River in Utah's Canyonlands National Park.

Prior to dam construction, the Green's extreme variability in flow, sediment concentration, and temperature gave rise to an array of fish—some thirteen endemic species in the minnow, sucker, trout, and sculpin groups—that were unique to the Green River.

All of these species are now threatened by changes to the river since the 1960s. Some were not dam-related; for example, many non-native fish species have been introduced to the river and compete for the same food and habitats as the natives.

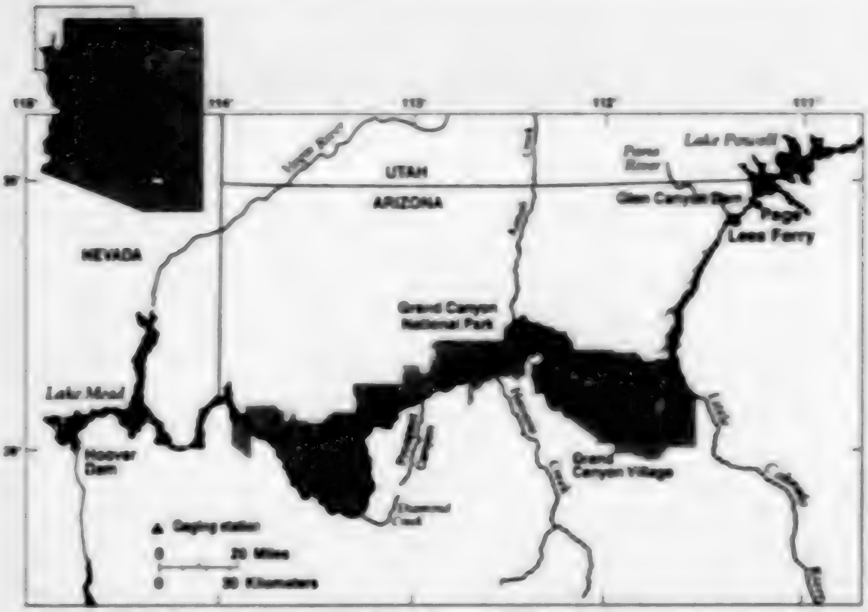
Some dam-related stresses were inevitable, while others did not have to happen. Just before the Flaming Gorge Dam was closed in September 1962, federal and state agencies dumped 21,500 gallons of rotenone into the Green River at various stations in Wyoming in an effort to kill some of the "rough" fish that might interfere with stocked trout. The effect of this experiment was to kill significant numbers of native fish, many of which are now threatened or endangered.

In the 1960s and 1970s, nearly half of the Green's total annual flow was diverted for agriculture, mining, power plants, and other uses. In 1980, the U.S. Fish and Wildlife Service used the authority of the Endangered Species Act to issue a Biological Opinion that water management had to be changed to protect the river's endangered fish species. In response, the operation of the Flaming Gorge Dam was adjusted. Dam releases are now seasonally adjusted to mimic the river's pre-dam flows and promote native fish habitat. Spring peaks are meant to facilitate spawning and protect young fish in backwaters. Studies are underway to link the creation and maintenance of habitat to sedimentary processes influenced by dam operation. Whether these changes will be enough to enable these fish to make a comeback is unclear.

Colorado River. The Colorado River and Grand Canyon National Park are among the nation's most popular destinations (Figure 3.10). John Wesley Powell took the turbulent passage down the Colorado in 1869. Today, some 22,000 people annually repeat Powell's adventure, while another 5 million view the river from the rims of Grand Canyon National Park.

Historically, an average of 12 million acre-feet of water rolled through Grand Canyon each year, with floods typically

Figure 3.10 The Colorado River Downstream from Glen Canyon Dam in the Grand Canyon, Arizona



Source: Collier, M., R.H. Webb, and J.C. Schmidt, *Dams and Rivers: A Primer on the Downstream Effects of Dams*, USGS Circular 1126 (USGS, Tucson, AZ, 1996).

occurring in May and June. Great volumes of sand were stored along the main channel; during floods, the sand would be deposited along higher terraces, creating beaches. These beaches remain an integral aspect of the river, nurturing a plant community of mesquite, catclaw, and hackberry, and providing camping sites for rafting parties.

Completed in 1963, Glen Canyon Dam was the cornerstone of the Colorado River Storage Project, a series of six dams on the Colorado, Green, San Juan, and Gunnison rivers. With Hoover Dam 280 miles downstream, Glen Canyon Dam helped provide flood control, irrigation, and municipal water supply for Arizona, California, and New Mexico. Lake Powell, a 26.7 million acre-foot reservoir created by the dam, provides recreation for millions of people every year.

In the mid-1970s, river runners and scientists noticed that some beaches were disappearing and that plant and animal life along the river was changing. In 1989, the Secretary of the Interior announced that an Environmental Impact Statement (EIS) would be required for continued operation of the dam. In 1992, Congress passed the Grand Canyon Protection Act, which stipulates that Glen Canyon Dam is to be

operated in a manner that protects resources within Grand Canyon, and that long-term scientific studies be conducted to monitor the downstream effects of the dam.

With increasing frequency, scientists have called for "beach-building" or "habitat-maintenance" flows. To this end, in March 1996 Glen Canyon spilled 45,000 cubic feet per second for eight days—the first intentional flood ever released for environmental purposes. When the flood receded, a great deal of clean new sand had been deposited well above the normal high-water line.

Periodic beach-building flows are an exciting new tool in dam management. But much needs to be learned about the ideal volume and length of such releases, about their impact on native fish and riparian vegetation, and about the amount of revenue lost because of bypassed electrical generation.

RESOURCE PRESSURES: MINING

In the lower 48 states, the upper reaches of most rivers are quickly affected by human activities. Mining, logging, residential development, and other factors all put pressures on headwater areas. Water quality in headwaters areas also can be altered by natural factors (Box 3.2).

Mining and resource extraction activities can present difficult conflicts between development and environmental objectives. In many cases, resource extraction has severe environmental impacts that can affect wildlife habitat, aquatic life and the safety of drinking water supplies.

Many current environmental insults are the result of past mining operations. In the upper Colorado river basin today, gold and silver mines operated in the late nineteenth century are a major source of water quality degradation. Trace metals are stored in stream bed sediments and interact with stream biota. Some of the affected streams are used for municipal supplies, or have recreation potential. In the Appalachian states, as discussed later in this chapter, abandoned coal mines are a frequent source of acid mine drainage.

Present activities also pose significant environmental problems. In northeastern Washington, for example, mining and smelting operations have contributed millions of tons of metal-rich sediment to the lakes and rivers in the area, causing ecological disruption, contamination of fish tissue, and possible human health risks. Examples include Lake Coeur D'Alene, which is nearly devoid of bottom-dwelling organisms, and Lake Roosevelt, which receives 300 tons of slag daily from a Canadian lead/zinc smelter.

On the Humboldt River in north-central Nevada, dewatering aquifers to allow continued deepening of open-pit gold mines has lowered water levels more than 500 feet. The volumes of water moved in dewatering are approaching the total urban water use in Las Vegas. Discharge of the mine waters to adjacent surface and groundwater basins has resulted in significant interbasin transfers.

Future mineral development also can be controversial. In northeastern Wiscon-

Box 3.2
The Impact of Natural Factors on Water Quality

In the absence of human activities, the chemical composition of streams and lakes is controlled by the release of minerals from rocks and soils, which in turn is affected by factors such as rainfall, temperature, evaporation, and by the life cycles of plants. Concentrations of calcium, magnesium, sodium, and potassium are generally correlated with the chemical composition of rocks and soils in a given drainage basin. In some relatively unusual cases, unmined mineral deposits can affect stream water quality.

The U.S. Geological Survey recently found significant leaching from undisturbed silver, lead, and zinc deposits in the northwestern Brooks Range in Alaska. Prior to mining, water quality in streams draining the Red Dog deposit were acidic and contained highly toxic levels of cadmium, lead, and zinc that exceeded the drinking water standards recommended by the state of Alaska. These contaminated waters were toxic to most aquatic life; streams immediately draining the deposit did not support any significant fish populations. Streams draining the undisturbed Drenchwater deposit had low pH values and high concentrations of dissolved solids (Box Figure 3.2). The most acidic water in the region (pH 2.8 to 3.1) is in False Wager Creek, which partly drains the deposit on the east side. These streams also contain high concentrations of dissolved aluminum, arsenic, iron, cadmium, copper, lead, manganese, nickel, and zinc. In most cases, concentrations exceed state safe drinking water standards. At the nearby Lik deposit, stream waters are in the neutral range for acidity and contain only zinc in consistently high concentrations. Carbonate rocks in the area neutralize acid in the water and lower its ability to carry most metals in solution.

A 1971 study on sources of sulfate in streams estimated that for North America about 40 percent was from natural sources and up to 60 percent was related to human activities. But scientists now realize that there is considerable variation in sources around the country.

For example, when the U.S. Geological Survey sampled the chemical composition of the St. Lawrence River at the entrance to Lake Ontario in 1906-7, sulfate (SO_4) concentrations were estimated at 9.7 tons per square mile. In 1969, some 60 years later, concentrations were estimated at 25.2 tons per square mile.

Although some of the sulfate in 1906 could have been the result of atmospheric deposition, scientists believe they largely represent the natural stream condition dating back into the 19th Century. The increase in sulfate is thought to be due largely to an increase in atmospheric sulfur contributions to the Great Lakes drainage basin.

Similar estimates of sulfate for the Columbia River at Northport, Washington, in 1910 found concentrations of 22 tons per square mile; in 1954, concentrations had increased only slightly to 25.8 tons per square mile. Natural sources of sulfate in the Columbia include mineral and thermal springs in the Canadian part of the river's drainage basin. The human contribution to sulfate concentrations seems to be a relatively minor part of the total.

In short, even without considering affects from human activities, stream water quality is affected by a complex interaction of chemical, geological and hydrological factors. No two river systems are exactly alike; each has unique characteristics that are not exactly duplicated in any other system. For a detailed discussion, see the multi-volume series by Ruth Patrick entitled *Rivers of the United States*.

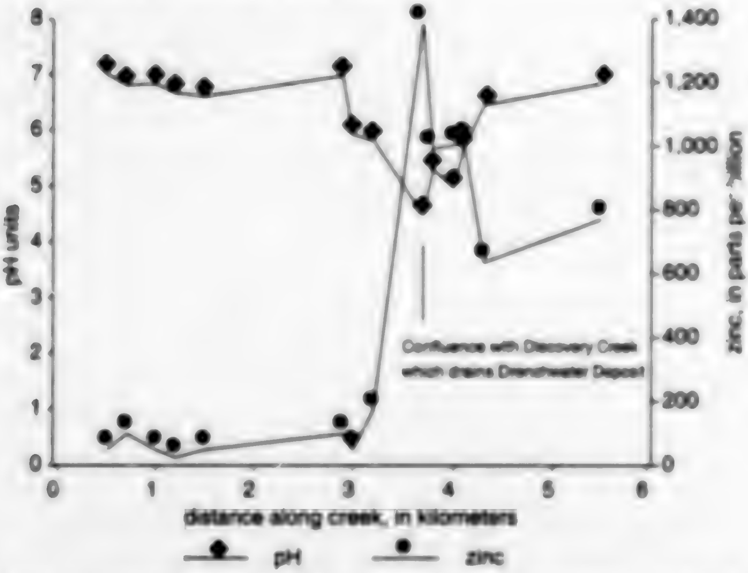
sin, the Wolf River is one of the last wild riverways in the Midwest and a component of the National Wild and Scenic Rivers system. It is one of the premier fishing and whitewater recreation rivers in the region, and has been recognized by the state for its excellent water quality.

Crandon Mining Company is proposing to develop an immense zinc/copper sulfide deposit at the Mole Lake Reservation near Crandon, Wisconsin. The company plans to put part of the mine's waste in a dump at the headwaters of the Wolf River. The estimated 44 million tons of mine waste – including mercury, lead, zinc, arsenic, and sulfuric acid – has prompted American Rivers, Inc., an environmental organization, to list the Wolf as one of the nation's 20 most endangered rivers.

In February 1998, the Wisconsin legislature approved the Mining Moratorium bill, which would require the Wisconsin Department of Natural Resources to refrain from issuing a permit for a new sulfide mine until a similar mine has been operated elsewhere for at least 10 years and has been closed for at least 10 years without polluting groundwater or surface water. Governor Thompson is expected to sign the measure into law.

The Blackbird mine site in the Salmon National Forest east of Salmon,

Box Figure 3.2 pH and Dissolved Zinc in Drenchwater Creek, Brooks Range, Alaska, July 1994



Source: U.S. Department of the Interior, U.S. Geological Survey, *Natural Environmental Effects of Silver-Lead-Zinc Deposits in the Brooks Range, Alaska*, USGS Fact Sheet 092-95 (USGS, Reston, VA, 1995).

Idaho, is one of the largest cobalt deposits in North America. Several companies have mined cobalt at the site since the late 1800s. Shaft methods were used through the late 1950s. Open-pit mining began in the late 1950s. Noranda Mining Company, which currently owns the site, ceased operations in 1982. At that point, the site included numerous waste rock piles, a 5-hectare open pit, about 24 kilometers of underground shafts and about 34 hectares of exposed contaminated mine wastes.

Mining tunnels, waste rock piles, tailing piles, and the open pit are located at the headwaters of Meadow and Bucktail Creeks, which drain into Big Deer and Blackbird Creeks. These creeks are part of the Middle Salmon River-Panther Creek drainage basin, which in turn is part of the Salmon River.

The site, which is on EPA's Superfund National Priorities List, has a variety of pollution problems, including acid drainage and leachate from the tunnels, waste piles, and tailings, plus high levels of heavy metals such as arsenic, copper, cobalt, and nickel. In 1983, the Idaho Attorney General filed a natural resources damage complaint against the current owner and two previous owners for alleged damages to the state's surface water and groundwater. The suit was settled in 1995.

In 1993, the potentially responsible parties initiated early actions to prevent further migration of the tailings, followed in 1995 by efforts to address the waste rock problem—including relocating some of the waste rock piles, intercepting groundwater and surface water for treatment, and capping an area and intercepting its groundwater for treatment. In late 1994, the potentially responsible parties, under EPA supervision, began to investigate the nature and extent of site contamination, which will be used to determine the most effective remedy for final site cleanup.

Panther Creek historically supported large runs of chinook salmon and steelhead trout, but these runs gradually declined during the 1940s when extensive mining activities began near Blackbird Creek. Since the early 1960s, the watershed has been largely uninhabitated by these species. Water quality degradation in Panther Creek from the Blackbird Mine seems to have been a significant factor in the decline of the chinook species, contributing to the now threatened status of the spring/summer chinook. Most of the salmon stock must pass through contaminated areas to reach suitable spawning grounds, and juveniles must migrate back through contaminated areas for summer rearing.

NOAA joined the state of Idaho and the Forest Service in a Natural Resource Damage Assessment in 1993, conducting extensive studies to determine the scope and scale of the damage and developing a restoration program. Major biological components of the restoration plan include:

- Restoration of spring/summer chinook salmon to Panther Creek. To accelerate run restoration, a fish barrier/trap and acclimation ponds will be maintained on Panther Creek for a period of time to capture returning adults and imprint juveniles.

- Realignment of 1.2 miles of a straightened and channelized section of Panther Creek to conform to its natural meander pattern to improve and create salmon and steelhead spawning and rearing habitat.
- Creation of off-channel habitat in Panther Creek to improve juvenile salmon rearing conditions.
- Fencing of 2 miles of heavily grazed private land along Panther Creek, and 5 to 8 miles of heavily grazed private land along other Salmon River Basin tributaries to allow regeneration of riparian vegetation and improve spawning and rearing conditions for salmon and steelhead.

All decisions regarding implementation will be made by a Trustee Council, comprised of representatives from NOAA, the Forest Service, and the state of Idaho. The trustees are working closely with EPA to ensure a coordinated, cost-effective remediation and restoration strategy. The consent decree settling the case requires the responsible parties to restore water quality in Panther Creek by 2002. The parties are also required to fund a program to reintroduce chinook salmon to Panther Creek, implement a Biological Restoration and Compensation Plan (BCRP) to restore and enhance salmon habitat in site-impacted and out-of-basin streams, fund trustee oversight of BCRP implementation, and reimburse trustees' past damage assessment costs.

Case Study: The New World Mine

In some especially sensitive headwaters areas, the prospect of even a single new mining project may bring unacceptably severe environmental risks. Such is the case with a recent proposal by Crown Butte Mines to develop a gold, copper, and silver mining complex less than three miles from the northeast border of Yellowstone National Park. The rights to the minerals at New World Mine had been obtained under the 1872 Mining Act.

The complex was to be located partially on private property and partially on public lands managed by the Forest Service. Most of the private lands at issue are held by Crown Butte or Ms. Margaret Reeb, a Montana resident who leased her lands to Crown Butte.

Crown Butte submitted a plan that called for 15 years of operation, with six major facilities, plus a 70-100 acre tailings impoundment behind a 90-foot-tall dam. The tailings impoundment was planned to contain the highly acidic waste rock and metals in perpetuity.

The New World proposal required preparation of an environmental impact statement under the National Environmental Policy Act. The EIS process began in April 1993.

A preliminary draft of the EIS showed that there could be major adverse impacts on the Clark's Fork of the Yellowstone River (a federally designated wild and scenic river), on grizzly bear habitat, and on Yellowstone National Park itself. Interagency review of preliminary drafts also showed a need for additional studies

to characterize groundwater conditions at the mine site and for a risk assessment of the proposed tailings impoundment. As a result of these findings, work on the draft EIS was extended.

The preliminary draft EIS was widely reviewed. Many analysists, including mining engineers, were critical of the submerged tailings system. Questions also were raised about: seismological risks in an area that had experienced more than 4,000 earthquakes within a 180-mile radius; the need for more analysis concerning containment of the 5.5 million tons of highly acidic waste rock that would be generated by the mine; the risks associated with the tailings impoundment; and the lack of information about the potential impact of the mine on groundwater.

In March 1995, Wyoming Governor Jim Geringer wrote Montana Governor Marc Racicot to say that the alternative preferred by the company could have a significant impact on Wyoming water resources and suggested that the tailings impoundment should be the subject of a separate review. Because of the highly acidic nature of the ore body at the New World mine, Governor Geringer suggested a bonding level of $75 million to $100 million. The company's plan of operations called for "dewatering" a portion of Henderson Mountain, and the Yellowstone Water Compact governing water flows into the park could have required Crown Butte to replace the diverted water. It was also abundantly clear that there would be years of contentious litigation over the mine, regardless of whether the federal government approved or denied the company's application.

In the face of this apparent stalemate, environmental groups and the company began discussing creative ways to resolve the conflicts. In February 1996, Crown Butte, Hemlo Gold (the Crown Butte parent company) and the Greater Yellowstone Coalition asked the Clinton Administration to consider transferring federal assets to Crown Butte in exchange for the company's agreement to drop any further pursuit of the mine proposal. After studying the proposal, the Administration agreed to further discussions. The discussions focused primarily on the value of the mine, cleanup and restoration of the environmental impacts associated with past mining, resolving a protracted lawsuit brought by environmental groups, and resolving potential federal enforcement actions.

On August 12, 1996, President Clinton and the parties announced an agreement. The essential details were that Crown Butte would agree to drop plans to develop the site, that the federal government would agree to transfer to Crown Butte $65 million in federal assets in exchange for title to all the lands essential to development of the mine, that the company would place $22.5 million in a trust fund to remediate historic environmental contamination in the area; and that the parties would agree to settle the existing litigation by the environmental groups and potential environmental claims by the federal government. The agreement was contingent on: 1) identification by the United States of $65 million in federal assets that could be

transferred to Crown Butte, and 2) Crown Butte's acquisition of the property it leases from Margaret Reeb.

After considering a wide variety of assets to exchange, Congress and the Administration ultimately decided to directly appropriate up to $65 million from the Land and Water Conservation Fund to acquire the Crown Butte/New World Mine property. The acquisition will be accompanied by an additional $12 million federal expenditure to improve and maintain the Beartooth Highway.

Acid Mine Drainage

Through the World War II era, coal was mined in Appalachia with little or no environmental control. Advances in technology gave the mining industry the capacity not only to mine coal more efficiently but also to disturb vast areas without reclamation at an alarming rate, both underground and on the surface, as mining became widespread. These new mining methods had two major impacts. First, fewer people were needed to mine greater quantities of coal. Declines in employment contributed to intense poverty and hardship. Second, the very lifeblood of thousands of communities, the streams and rivers, became so heavily polluted by acid and heavy metal contamination that they supported little or no life and were of limited use for drinking, agriculture, recreation, or aesthetic enjoyment.

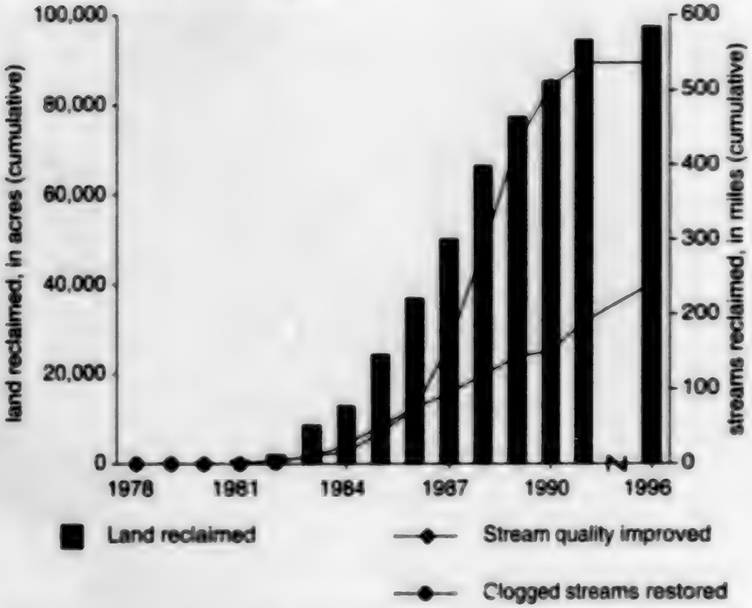
Acid mine drainage (AMD)—water containing high concentrations of acidity, iron, manganese, aluminum, and other materials—is the number-one water pollution problem in the Appalachian region and has damaged more than 8,000 miles of streams and rivers in the eastern United States (Figure 3.11). Most acid drainage originates in abandoned underground coal mines and is carried by surface or groundwater into nearby streams. Affected streams are typically devoid of fish and other aquatic life due to low pH levels and the smothering effects of iron and other metals deposited on the stream beds. Acid mine drainage also can impair drinking water supplies, interfere with river recreation, and harm communities' economic development.

In the Allegheny River subbasin, a chain of industrial river valleys and min-

Figure 3.11 Streams Affected by Acid Mine Drainage

Source: Executive Office of the President, Council on Environmental Quality, *Environmental Trends* (GPO, Washington, DC, 1989).

Figure 3.12 Abandoned Coal Mine Land and Stream Reclamation, 1978-1996



Source: U.S. Department of the Interior, Office of Surface Mining Reclamation and Enforcement, *Surface Coal Mining Reclamation: 20 Years of Progress, 1977-1997*, Part 2, Statistical Information (DOI, OSMRE, Washington, DC, forthcoming) and earlier reports.

ing towns east of Pittsburgh, 775 miles of streams are impacted by acid mine drainage. In the 130 miles of impaired streams in the Upper Allegheny Subbasin, resource extraction is a source of pollution in nearly 60 percent of the affected stream miles.

The problem is caused when surface or underground mining operations expose coal and bedrock high in pyrite (iron sulfide) to oxygen and moisture. If produced in sufficient quantity, the iron hydroxide and sulfuric acid that result from chemical and biological reactions eventually contaminate surface water and groundwater.

Filling or sealing old shafts to eliminate acid production is expensive, and the results have been inconsistent. Water treatment, the other main option, involves two types. "Active" treatment usually involves neutralizing acid-polluted water with hydrated lime or crushed limestone. This treatment reduces acidity and significantly decreases iron and other metals, but is expensive to construct and operate, requires constant maintenance, and does not permanently eliminate the problem.

Biological, or "passive," control involves the construction of a treatment system that is more permanent and requires little or no maintenance. Passive

control measures include the use of anoxic drains, limestone rock channels, alkaline recharge of groundwater, and diversion of drainage through man-made wetlands or other settling structures. Passive systems are relatively inexpensive to build and have been very successful in controlling some small discharges of acid drainage, but these technologies are still relatively new and their long-term effectiveness has not been proven.

The federal government has been actively engaged in dealing with acid mine drainage for several decades. The 1977 Surface Mining Control and Reclamation Act created a fund for abandoned mine land (AML), which is supported by tonnage-based fees collected from coal producers. Each year Congress appropriates money from the fund for reclamation projects. Coal companies paid in $266 million in FY 1997 to the fund and Congress appropriated $174 million in FY 1997. As of September 1997, there was $1.2 billion in the fund's unappropriated balance.

Historically, abandoned-mine-related water quality problems were not considered a top priority, making it difficult for states and tribes to fund a significant number of reclamation projects. (The law requires that one half of the funds collected within a state or Indian tribal boundaries be reserved for use by that state or Indian tribe. To receive a grant, a state or Indian tribe must have a reclamation plan that has been approved by the Secretary of Interior.)

In 1990 the law was amended to include adverse economic impacts on a community as a reason for giving priority to the reclamation of certain sites. Beginning in 1995, Interior's Office of Surface Mining (OSM) encouraged states and tribes to consider whether acid mine drainage pollution sites could be considered "general welfare" problems that had an adverse economic impact on a community. Such an interpretation gives these water problems a higher priority and allows them to compete more easily for limited AML dollars. The law also provides that up to 10 percent of the annual grants to states and tribes may be set aside in state-managed accounts for use in cleaning up mine drainage problems. OSM also has determined that funds in these accounts can be used to match other federal grants for stream cleanup projects. In the FY 1997 appropriation, Congress authorized states and tribes to use any of the AML grant funds to match other federal dollars, as long as the purpose is environmental restoration related to treatment or abatement of acid mine drainage from eligible abandoned mines and if the project is consistent with the law's purposes and priorities. Progress to date is shown in Figure 3.12.

The Appalachian Clean Steams Initiative. In the 1960s and 1970s, dozens of federal agencies and all states had some jurisdiction over mine drainage, but communication among these groups was practically nonexistent.

To help break down these barriers, OSM in 1995 started a new program called the Appalachian Clean Streams Initiative. The Clean Streams Initiative has a simple, but challenging mission: unite all parties to clean up streams polluted by mine drainage. The initiative

encourages increased information exchange, multiagency coordination, and the formation of partnerships among government, citizens, and corporations to bring innovative solutions to this national problem. The initiative is a watershed-based, grassroots partnership and alliance with over 40 state, federal and local organizations dedicated to stream cleanup.

In FY 1996, the Clean Streams Initiative team established a clearinghouse for information and technology on acid mine drainage and a World Wide Web site. A working group with the states and the International Association of Fish and Wildlife Agencies identified and ranked candidate projects, and proposed a pilot program to clean up 236 miles of streams in nine states at a cost of about $22 million. The group estimated that the projects would generate $6 million in economic benefits yearly in increased recreation and fishing. Congress authorized $4 million for an initial grants program covering 14 projects in nine states. For most of these projects, these grants provide only "seed" money; additional funding must be arranged through cooperating government agencies and private sector groups.

All told, these projects will clean up almost 200 miles of streams. For example:

- Restoration of Cane Creek, which is within the Wolf Creek Wildlife Management Area in Alabama. Phase I of the Cane Creek project, which is completed, helped restore a 20-mile multi-species fishery on public land and eliminated a hazardous sinkhole. This project was strongly supported by the citizens of the region, several state agencies and the U.S. Fish and Wildlife Service.
- The first phase of the Quemahoning Creek project is completed. This project will restore about 15 miles of fishery and improve a public water supply to Farrellton, Pennsylvania. This project has strong support from several federal agencies, as well as state, county, local and private groups.
- Little Toby Creek in Pennsylvania is a wadable, fast-flowing cold water stream in an area of historic and widespread mining impacts. A proposed restoration would support the area's inclusion into the Wild and Scenic River System, create a trout fishery and other recreational benefits, and generate economic benefits to the nearby communities.

An additional Clean Streams Initiative achievement is the accelerated development of low cost, reliable technologies for acid mine drainage treatment and prevention, such as constructed wetlands and other passive systems. Project partners, including the mining industry, started an Acid Drainage Technology Initiative to identify best science and technology for AMD prediction, avoidance, and abatement.

Clean streams return benefits to the local area many times greater than the initial investment. Clean drinking water improves the general health of the population by reducing sulfates and heavy metal contamination that are common results of acid mine drainage. Clean rivers and streams benefit agriculture, recreation, tourism, and navigation.

Industries that depend on clean water often bypass Appalachian towns in part because their streams are polluted by acid mine drainage. The dirty waters reflect poorly on the community and diminish the pride people take in their hometowns. Cleaning up these eyesores could make the difference in attracting new businesses and laying the foundation for sustainable economies.

Because of the clean streams initiative, several new citizen watershed groups have formed to clean up and protect streams and rivers and many other citizen groups with an environmental or clean water agenda have become more active. These groups are taking an active role and helping to set the the Initiative's agenda and priorities. The Clean Streams Initiative team has received Vice President Gore's Hammer Award for its innovative approach to government reinvention.

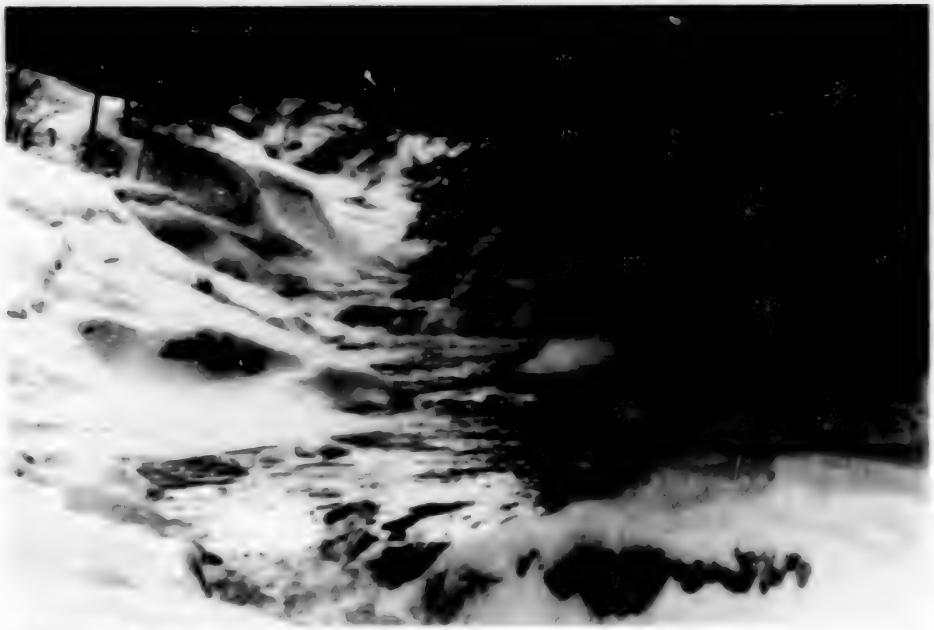
RESOURCE PRESSURES: TIMBER

Timber harvesting can have a wide variety of impacts on stream water quality and aquatic resources. The range and extent of impacts are influenced by factors such as climate, topography, soils, and proximity to water bodies.

One of the most significant impacts is the road-building infrastructure created to carry out timber operations. In the Pacific Northwest, which has been intensively studied in recent years and is the primary focus of this discussion, road networks in many upland areas are the most important source of sediment delivery to streams and rivers. The contribution of roads to stream sedimentation is often much greater than all other land management activities combined.[3] Road-related landslides, surface erosion and stream channel diversions frequently deliver large quantities of sediments to streams, both chronically and catastrophically during large storms. No matter how well they are located, designed, or maintained, roads may have unavoidable impacts on streams. Many older roads with poor locations and inadequate drainage control and maintenance pose high risks of erosion and stream sedimentation.

Stream crossings are especially vulnerable elements of road networks. Within the range of the northern spotted owl in the Pacific Northwest, there are approximately 110,000 miles of roads on federal lands and about 250,000 stream crossings (culverts). The majority of these crossings cannot tolerate more than a 25-year flow event without failing. Over a 30-year period, there is a 70 percent chance that such an event will occur. When stream crossings fail, a local flood usually occurs, resulting in severe impacts on water quality and habitat.

Roads modify natural hillslope drainage networks and accelerate erosion processes. Where roads slope to a ditch, the ditch extends the drainage network, collects surface water from the road surface, and transports this water quickly to streams. In watersheds of 20-200 square miles in the Pacific Northwest, increased peak flows have been detected after road construction and clearcutting occurred.



A stream in central New Hampshire

Photo Credit
S.C. Delaney/EPA

though there is considerable variability among sites. Removing forest vegetation alters hydrological processes such as rain or snow interception and snow accumulation and melt, which tends to increase the amount of water flowing from a logged watershed.

In many watersheds, peak flows appear to rise in a nonlinear fashion with increased timber harvest. Hydrologic impacts may appear when less than 20 percent of a watershed is clearcut. For example, peak winter storm flows increased 13 percent after 19 percent of a coastal British Columbia watershed was clearcut. In the rain-dominated systems of the Coast Range, clearcutting two thirds or more of a watershed may increase fall peak flows by about 50 percent and winter peak flows by 20-30 percent.

These alterations tend to be most severe immediately after timber harvesting and gradually diminish over time, but the alteration of hydrological processes can continue for three to four decades. The long-term impacts of logging also depend on the types of trees that dominate the landscape before and after harvest. One study of a stream in Oregon's Cascade Range found that August flows increased for 8 years following logging, but decreased for 18 of the next 19 years. The authors attributed the reduction in streamflow to the replacement of coniferous vegetation with more water-consumptive hardwood species.

These changes can have significant biological consequences that affect virtually all components of stream ecosystems. Increased levels of sedimentation can

reduce the survival rates of fish eggs in spawning gravels, reduce the availability of food for fish, and disrupt social and feeding behavior.

Timber harvesting can also reduce the complexity of aquatic habitats, which is an important indicator of the quality of aquatic ecosystems. Trees in streams are an important factor in creating large pools, which are preferred habitat for fish species such as salmon. Reducing wood in the channel generally reduces the quantity and quality of such pools. Within the range of the northern spotted owl in eastern and western Washington, it is estimated that in the past 50 years there has been a 58 percent reduction in the number of large, deep pools in resurveyed streams on National Forests. On private lands in coastal Oregon, it is estimated that large pools have decreased by 80 percent.

Bridge approaches and streamside roads tend to reduce stream meandering and decrease pools formed by stream meanders. Road failures on steep slopes can cause severe sedimentation that can result in the loss of pools.

Logging in riparian areas has a variety of environmental impacts. Loss of streamside vegetation reduces shade and tends to increase stream temperatures, with subsequent adverse impacts on fish and other aquatic life. The roots of trees and shrubs play an important role in stabilizing streambanks. Timber harvesting and the subsequent loss of root strength may lead to increased incidence of debris slides and flows.

For coniferous forests of the Coast Range and western Cascades, increases in average summer maximum temperatures because of clear-cutting have ranged from about 3 to 8 degrees Centigrade. Increases up to 10 degrees Centigrade have been observed when clear-cutting has been followed by slash burning. The cumulative effects of temperature increases are less well understood. One study of the Needle Branch in Oregon's Coast Range found that stream temperatures returned to near normal conditions after years, with alders replacing conifers as the dominant riparian vegetation. Other studies suggest that elevated temperatures may persist for two decades or more. In the higher elevation fir zone of the Cascades, shading may not return to prelogging levels for 40 years or more. For more on the impacts of riparian vegetation loss, see Chapter Four.

Case Study: Bitterroot National Forest

Applying ecosystem-based management approaches to real-life situations is an extraordinarily complex challenge. One effort is currently underway in the Bitterroot National Forest in western Montana and northeastern Idaho. This national forest, which includes grassland, forest, and alpine ecosystems, surrounds a valley that is both agricultural and urban and is experiencing rapid development. As with most national forests, forest managers must protect species and structural diversity in this landscape and also provide commodities and other benefits to the public.

The Bitterroot Ecosystem Management/Research Project addresses these

challenges through a science-management partnership. The project brings together people and resources from the Rocky Mountain Research Station, the University of Montana, several management levels in the National Forest System, and the public. Cooperators have matched the value of the project's original grant.

Four teams of specialists investigate questions relating to social aspects of ecosystems, landscape analysis, vegetation, and fauna. For example, the Human Dimensions Research Group is attempting to integrate the needs of local residents and forest owners with other aspects of management. In one unit, the Stevensville West Central area, more than 20 meetings were held to determine public perceptions, needs, and desires in relation to management. Followup research showed diverse ways of viewing the success of the public involvement effort; many viewed mutual learning as an important aspect of success. An evaluation of the use of collaborative methods in the Bitterroot Valley and other areas in western Montana identified 10 characteristics of successful programs, including participation by the agency representatives with decision-making authority.

The Vegetation Research Group describes current conditions and processes in Bitterroot forest and grassland communities. Demonstration projects have been initiated to regenerate whitebark pine, restore ponderosa pine and western larch, and reduce fire hazard in the wildlands near communities. The Fauna Research Group has investigated the status of several mammal species, aquatic insects, and migrant birds in Bitterroot ecosystems.

The Landscape Analysis Research Group has developed a geographic information system and models that analyze change in forest ecosystems and management options on a landscape scale. Managers have used results from these models to develop alternative treatment strategies for one planning area. Subsequent model runs designed to optimize various benefits produced results that managers incorporated into final alternatives. Scientists report results after completing each major phase of the research. Subsequent research is sometimes modified to answer questions from managers or the public. Dialogue with the public has been an important part of the effort. Education and communication efforts have included formal workshops to present results and address questions; displays and informational materials; progress reports for the public; several public field trips to demonstration sites; and educational materials for students. An Internet site (www.forestry.umt.edu/bemrp) describes the project and individual studies.

THE POWER OF PARTNERSHIPS

While in some cases, such as New World Mine, a single source can threaten a headwaters ecosystem, it is often the case that threats are multiple in nature and principally attributable to general development pressures. Many examples now point to the value of collaborative partnerships in working through these complex situa-

tions. Two examples are cited here: Lake Tahoe and the Upper Clark Fork River Basin in western Montana.

Case Study: Lake Tahoe

Lake Tahoe, which is renowned for the clarity of its water and the scenic beauty of its surrounding forests, lies on the California-Nevada border between the Carson Range to the east and the Sierra Nevada Range to the west. The lake is 22 miles long and 12 miles wide, with a surface elevation of 6,223 feet above sea level and a maximum depth of 1,645 feet, making Lake Tahoe the tenth deepest lake in the world. A short growing season, together with highly erodible soils and steep slopes, makes the lake and basin particularly susceptible to erosion, surface runoff, and water quality degradation.

Lake Tahoe is a popular destination for tourists seeking water sports, skiing, gaming, and other entertainment. Propelled by the Squaw Valley Winter Olympics in 1960, the population increased over five times. The current year-round population is estimated at 52,000, and the summertime population can swell to 300,000.

Historically and even today, Lake Tahoe is notable among the world's great mountain lakes for the clarity of its waters. Over the last 40 years, however, lake clarity has diminished by about 1 foot per year on average (Figure 3.13). Concurrently, algal growth in the lake is increasing at a rate of about 5 percent per year and contributing to an increase in primary productivity levels (Figure 3.14).

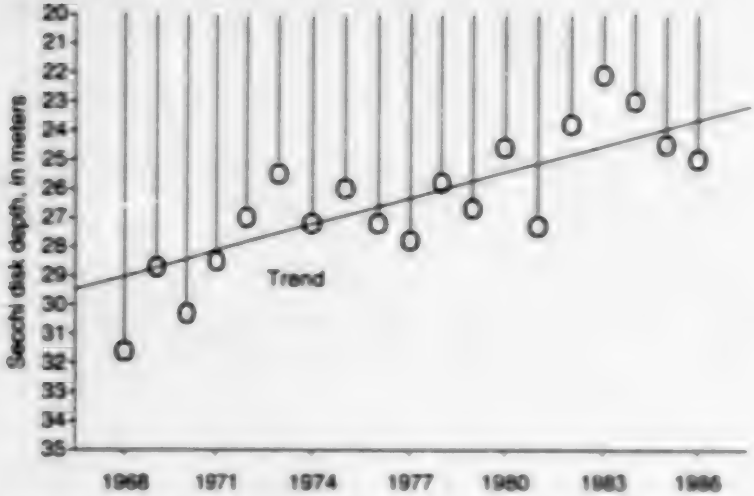
Research has shown that the algae are stimulated by nitrogen, phosphorus, and some micronutrients such as iron. Land development in the basin has increased the rate of sedimentation and fertilization and thus nutrient transport. Other sources, including in-lake nutrient recycling and precipitation, also contribute to the problem.

In-lake nutrient recycling is more dynamic than previously thought. The traditional belief was that nutrients deposited would soon sink well below the surface and not be available to algae. But in 1983, and again in 1993, scientists observed major "turnover" events in the lake. In the 1993 event, it was estimated that nutrients recycled from the deeper zones of the lake exceeded several years of input from all the tributary streams.

Scientists also believe that precipitation brings another significant source of nutrients to the Lake Tahoe basin. The principal source of nitrogen in precipitation is thought to be automobile emissions, but the share of the emissions attributable to local traffic (as opposed to outside sources) is not known. Traffic congestion is clearly getting worse in the region: daily traffic counts on the access routes to the region increased by an average 9.2 percent annually between 1981 and 1990.

Forest health is another significant environmental problem in the Tahoe basin. Lake Tahoe's Ponderosa-pine-dominated forest was leveled in the 19th Century to provide timber for the silver mines of the Comstock Lode in Virginia City. As the young pine and fir trees that replaced the old-growth forest matured, a

Figure 3.13 Annual Average Secchi Disk Depth at the Index Station, Lake Tahoe, 1968-1986



Source: Lahontan Water Quality Control Board, *Water Quality Plan for the Lahontan Region* (1994).
Note: A Secchi disk measures water clarity, an indicator of water quality. The disk is lowered overboard tethered by a line with graduations, and a measurement is taken when the disk disappears from view.

combination of factors – lack of thinning, exclusion of natural fires, and above-average rainfall – produced the current overcrowded forest of even-aged trees and dense undergrowth. These overstocked forests were hit hard by the prolonged drought from 1986 to 1994, which precipitated a bark beetle infestation that caused widespread tree mortality. The 25-30 percent tree mortality in the basin has created a dangerous fire hazard. Forest fires could threaten the basin's soil, water, and wildlife habitat, as well and human lives and property. Extensive salvage harvests could reduce the fire hazard, but could also create serious water quality problems.

In 1969, at the joint request of the states of California and Nevada, the Tahoe Regional Planning Agency (TRPA) was established by federal law as a bi-state planning and regulatory agency, to better manage growth and to protect the lake and its surrounding environment.

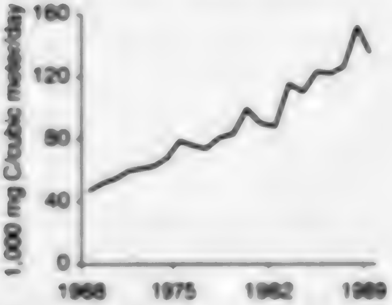
TRPA developed a regional plan intended to control the rate of growth of housing and other development and protect the lake's water quality. Under the plan, new home construction in the basin was limited to 300 units per year, and new construction in "stream environment zones" – generally areas that owe their biological characteristics to the presence of surface water or groundwater – was banned. Transferable development rights were granted to all property owners, including those whose property value might be lost, either in whole or in part, by the ban. These rights could be sold to developers of less environmentally sensi-

tive land. Limits were placed on the "foot-print" of buildings, and additions or major remodeling were subject to strict controls to avoid environmental problems.

Under the plan's Individual Parcel Evaluation System (IPES), all undeveloped residential lots were evaluated and scored for their suitability for development based on factors such as relative erosion hazard, runoff potential, ability to revegetate, and proximity to the lake. In 1989, the agency established a minimum score of 725 to qualify for development; properties with lower scores could not be developed. Properties located in stream environment zones received a score of zero, thus precluding development. Owners of property in stream environment zones were given transferable development rights for use on an eligible property in the Lake Tahoe region.

These development controls have proved controversial, particularly among property owners in stream environment zones and other property owners seeking to build new facilities or extensions of older facilities not in compliance with regulatory requirements. Two cases claiming a "taking" of property rights are pending in the federal court system. There have been calls for TRPA to complete permitting actions within 120 days, which would effectively streamline the project review process.

Figure 3.14 Annual Primary Productivity Levels at the Index Station, Lake Tahoe, 1968-1989



Source: Lahontan Water Quality Control Board, *Water Quality Plan for the Lahontan Region* (1994).

As part of its general budget retrenchment in the last few years, California legislators have passed across-the-board cuts in state agencies, including California's two-thirds share of TRPA's budget. In 1996, a California Assemblyman sympathetic to the criticisms about development restrictions sought to withhold California's entire share of the TRPA budget. The defunding initiative was defeated, but the state required TRPA to use part of its budget to perform a major performance audit. Subsequently, in response to criticisms from Nevada legislators that this required Nevada to pay part of the cost of an audit they considered unnecessary, an alternative source of funds was found.

After 10 years of emphasis on the regulatory approach to controlling the impacts of new development, TRPA is shifting its focus towards facilitating capital investment in environmental improvements. The agency has drafted a proposed 10-year, $900 million environmental initiative that calls for a variety of programs, projects, and regulatory amendments that are primarily intended to reduce erosion and lake sedimentation. The partnership will be supported by $300 million in federal funds, $275 million from the state of California, $85 million from Nevada, and

Tranquil edge of a lake in California.

Photo Credit
John Rusnak/USGS

the rest from local government and private sources.

In July 1997, President Clinton issued an executive order creating the Tahoe Federal Interagency Partnership, which is intended to facilitate coordination of federal programs and activities within the Lake Tahoe region and promote cooperation with state and local agencies. The president pledged $50 million in assistance (including $26 million in new federal funding) to protect Lake Tahoe and support TRPA's environmental improvement initiative.

Regional officials also are looking at various ways to ameliorate the traffic congestion problem. With the help of a $2.5 million grant from the Environmental Protection Agency and Department of Transportation, the region is supporting a demonstration project called the Coordinated Transit System (CTS). CTS will merge existing public and private transit services into a bi-state, centrally operated, centrally dispatched system that passengers will access via touch-screen kiosks at shopping areas, hotel lobbies, or through a voice-mail telephone system. The system will dispatch a roving fleet vehicle and notify the passengers of the time when they will be picked up.

Case Study: Upper Clark Fork River

The Clark Fork River is a Columbia River tributary that drains most of Montana west of the Continental Divide. The

case was described in a recent report by the National Academy of Public Administration, entitled *Resolving the Paradox of Environmental Protection*.

Community-based efforts in this region are particularly challenging because of the sharp conflicts over resources and environment that have characterized the area for nearly a century. In Butte, near the headwaters of the Clark Fork River, lies a massive open pit that once produced millions of dollars of copper ore for the Anaconda Mining Company.

Mine tailings from the Butte pit have traveled as much as 120 miles down the Clark Fork, making it the nation's largest superfund site. ARCO bought Anaconda in the 1970s and later sold the company, but was not able divest itself of Anaconda's superfund liabilities. Cleanup is underway, but the state of Montana has sued ARCO for $730 million to repair damage to the valley's natural resources.

Downstream, the river flows through some of the oldest ranching country in the state. Much of the area is still open ranch land, but residential development is occurring in some parts of the valley.

In 1988, the Northwest Area Foundation awarded a grant to the Northern Lights Institute, a small environmental organization in Missoula that was interested in promoting a civic dialogue on environmental issues. The grant was intended to build a coalition to address environmental issues in the Upper Clark Fork Basin.

As a first project, Northern Lights tackled the always controversial issue of water rights. The specific issue at hand was a pending attempt by the state Department of Fish, Game, and Parks to file legal claims for instream flows in the Upper Clark Fork River. State legislation passed in 1969 and 1973 gave the department the right to "reserve" instream flows sufficient to protect trout populations and to protect other ecosystem services. But the department's initial efforts to reserve water under the statute proved very controversial, pitting lawyers for the department against lawyers from mining companies and rancher-controlled local conservation districts. Ranching, mining, and municipal water supply had always been legally beneficial uses, with individual rights determined by the seniority of the claim.

By 1989, the department had completed an environmental impact statement on how instream flows might benefit fish in the Upper Clark Fork Basin. Agricultural interests were thinking about filing suit, environmentalists were prepared to intervene on the side of the department, and a local conservation district wanted to build a dam on a side creek to store water for use by ranchers in the summer. ARCO also was part of the picture, since it had sold its water rights along with its mining properties and needed water rights to use for the superfund cleanup.

Northern Lights organized a committee of ranchers, environmentalists, businesses, and state and local government officials to study the state of the Upper Clark Fork River. In January 1991, the committee asked the state legislature to suspend the normal processes for allocating water rights until it could write a management plan for the river.

The collaborative effort used a variety of tools to build consensus, including

seven public hearings, field trips, publication of articles, briefings on conditions in the basin, and discussions of technical issues. Gerald Mueller, the director of Northern Lights, played an important role as a facilitator. As the process unfolded, mutual trust and loyalty to the process increased.

The steering committee submitted its report to the legislature in 1995. The report recommended that the legislature enable the Department of Fish, Wildlife, and Parks to lease water from ranchers and farmers, and convert those water rights into instream flows. That would allow water being used for irrigation to be left in the river to support fisheries. The report also proposed to use wastewater from the Deer Lodge city treatment plant to irrigate pasture at a National Park Service ranch, which would remove the largest single source of nutrient pollution from the upper river. The legislature adopted virtually all of the management plan.

The story of the Upper Clark Fork Steering Committee adds further credence to the growing conviction that community-based approaches can break through gridlock, avert litigation, and protect the environment while also achieving other community goals.

The authors of the case study concluded that state and federal agencies can provide essential financial and technical assistance, but must refrain from overwhelming community-based efforts. Like other participants, the National Academy of Public Administration found that state and federal officials must be prepared to reconsider the current positions of their agencies, to think creatively for fresh ways to address local issues, and to have authorization from their superiors to actively participate.

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116

CHAPTER FOUR

The Rural River

Farmers and ranchers are less than 1 percent of the nation's population, yet they have the responsibility to manage and conserve roughly half the land in the lower 48 states—about 1,049 million acres.

For virtually every agricultural enterprise, a big part of the management and conservation challenge involves water, which is both a critical source of sustenance for crops and a vehicle for the movement of pollutants.

Surface water or groundwater used for irrigation accounts for about 34 percent of the total water withdrawn in the United States (including water applied both to agricultural crops and pastures and to recreational lands such as golf courses). Of the amount withdrawn for irrigation, about 90 percent of the total is in the West, where irrigation converts arid land into fertile cropland. In the East, irrigation is used to supplement natural precipitation, increase yields or the number of plantings per year, and reduce the risk of crop failures during droughts (See Table 4.1 and Figure 4.1).

In 1995, about 134 billion gallons per day was used for irrigation nationwide, with about 63 percent of the total withdrawn from surface water and the remainder from groundwater. Once withdrawn, about one fourth is lost in conveyance, half is consumed, and the remaining fourth is returned to surface water or groundwater supplies.

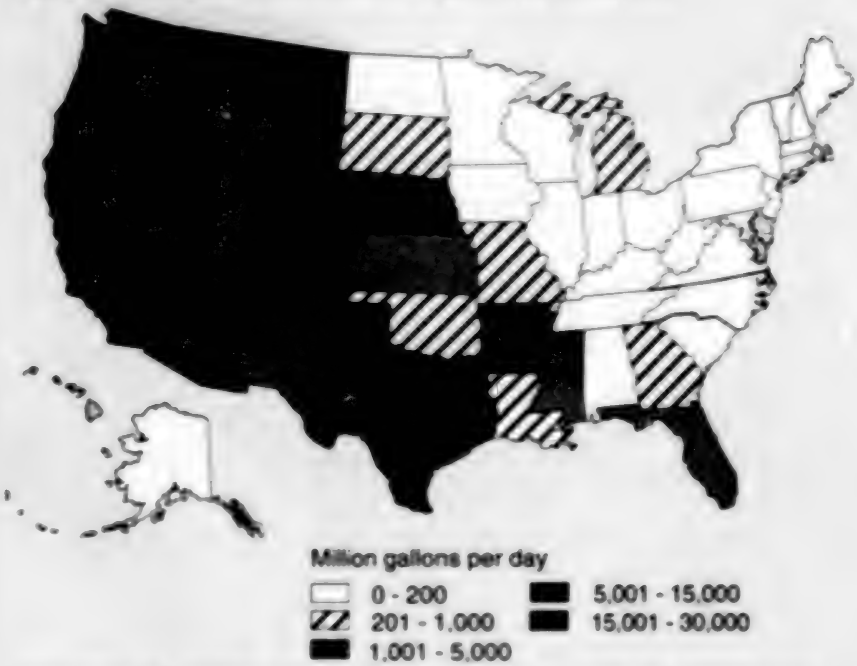
According to the National Water Quality Inventory, agriculture is by far the leading source of pollution in U.S. rivers and streams. But the extent of agricultural activities in a given watershed is not necessarily correlated with the severity or

Table 4.1 Diversion of Surface Water for Various Uses in Western and Eastern United States, 1990

Use	West	East
	percent	
Irrigation	76	24
Thermoelectric power	13	60
Municipal	8	9
Industrial	2	7
Livestock	1	0
Total	100	100

Source: Congressional Budget Office using data from W.B. Solley, R.R. Pierce, and H.A. Perlman, *Estimated Use of Water in the United States in 1990*, U.S. Geological Survey Circular 1081 (USGS, Reston, VA, 1993).

Figure 4.1 Amount of Water Used for Irrigation by State, 1995



Source: Solley, W.B., *Preliminary Estimates of Water Use in the United States, 1995*, Open File Report 97-645 (USGS, Reston, VA, 1997).

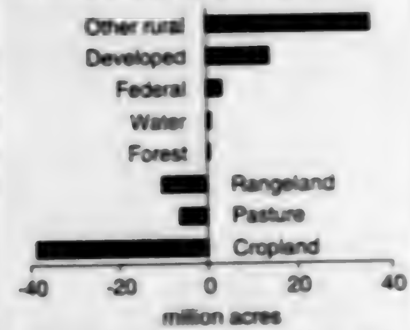
extent of water pollution problems. For example, there are many instances where the intensity of agricultural land use — such as the proliferation of poultry and concentrated animal feedlot production in the Southeast — is a leading factor in creating significant water quality problems.

CONSERVING THE LAND

Though agriculture still dominates the rural landscape, significant shifts are underway in the use of rural land across the nation (Figure 4.2).

For example, the number of mid-size farms has dwindled, while the number of small and large farms has increased. The pattern of increasing small ownerships, coupled with population growth as urban areas expand, has greatly increased the mixing and overlap of urban and rural land uses as evidenced by the value of agricultural production in proximity to metropolitan areas (Figure 4.3). Rural residential development now frequently mixes with prime farmland, which can make agricultural production more difficult and land management more complicated. Watersheds where the maintenance of healthy conditions formerly

Figure 4.2 Net Changes in Use of Nonfederal Land, 1982-1992

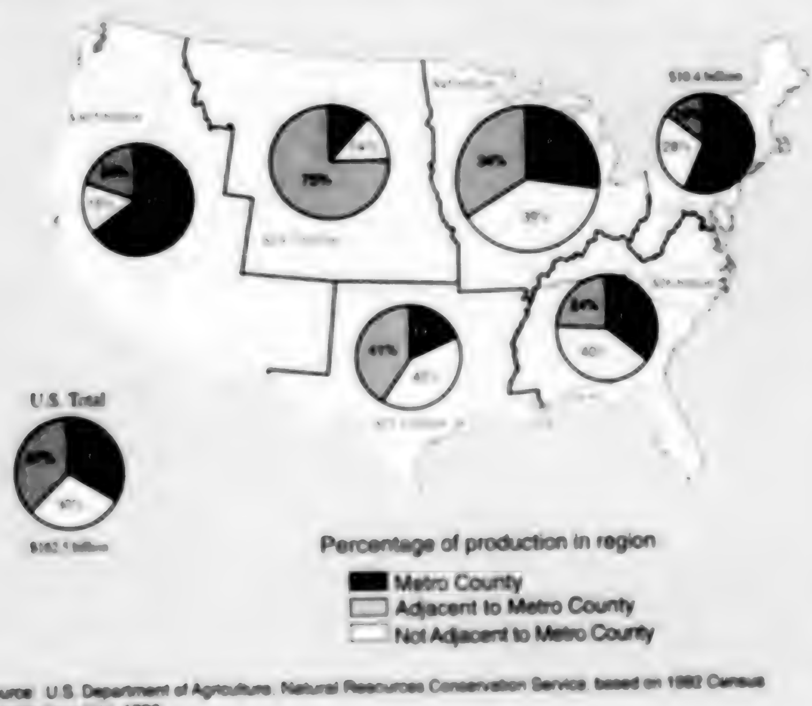


Source: USDA, Natural Resources Conservation Service, *Summary Report 1992 Natural Resources Inventory* (USDA, NRCS, Washington, DC, 1995).
Notes: Other rural land = primarily CRP acres, but also farmsteads, windbreaks, wetlands, and barren land. Federal = land acquired for national forests, parks, etc.

depended on the stewardship of a few dozen farmers may now require the cooperation and involvement of hundreds of small landowners.

Between 1982 and 1992, some 60 million acres shifted from cropland to other uses, while about 21 million acres shifted from other uses into cropland, leaving a net loss in cropland of 39 million acres. An important contributor to this shift in use was the federal Conservation Reserve Program (CRP), under which farmers retire highly erodible land from active use. Over the 1982-92 period, 35.4 million acres were enrolled in the CRP (See Part III, Table 7-19).

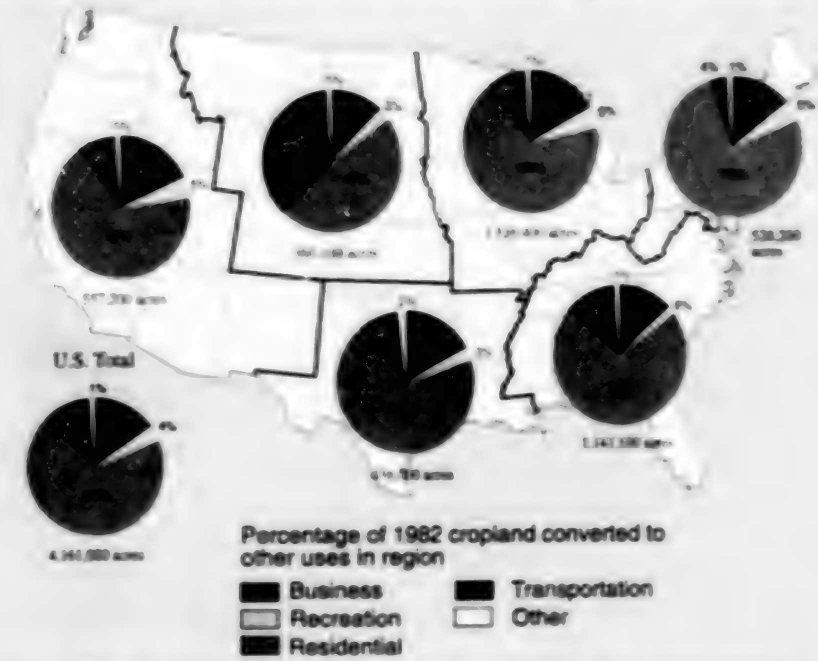
Figure 4.3 Value of Agricultural Production by Proximity to Metro Areas



Source: U.S. Department of Agriculture, Natural Resources Conservation Service, based on 1992 Census of Agriculture data, 1996.

Note: U.S. pie chart is not on same scale as regional pies.

Figure 4.4 Cropland Converted to Developed Land by Region, 1982-1992



Source: U.S. Department of Agriculture, Natural Resources Conservation Service, based on National Resources Inventory data, 1992.

Note: Pie charts are not to scale.

Over the same period (1982-1992), about 4 million acres were converted to developed land (Figure 4.4). About two thirds of this total was converted to residential development. However, the rate of conversion to residential development has slowed compared to earlier decades.

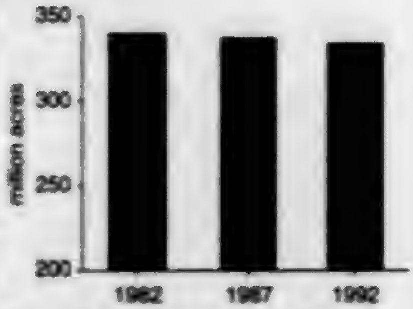
Saving Prime Farmland

The loss of prime farmland (Figure 4.5) has prompted the development of farmland preservation programs. Fifteen states, mostly in the Northeast, now pay farmers willing to keep their land in an agricultural use. Easements stay with the land even after its sale, guaranteeing that farmland stays farmland.

Since the mid-1970s, farmland preservation laws have protected nearly 420,000 acres of farmland at a cost of almost $730 million, or about $1,750 an acre. Funding for the programs has come mostly from sale of bonds and the levy of sales, property, and other taxes. An additional $195 million was available early in 1996 for further purchases, including $107 million in New Jersey alone.

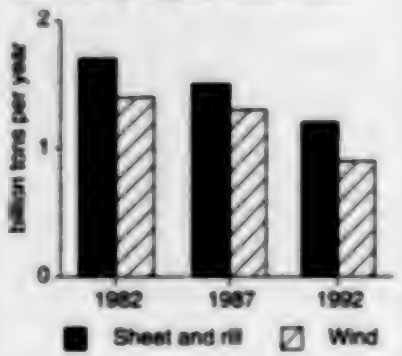
Maryland leads the way in farmland protection, spending $125 million to pur-

Figure 4.5 U.S. Prime Farmland, 1982-1992



Source: U.S. Department of Agriculture, Natural Resources Conservation Service, Summary Report 1992 National Resources Inventory (USDA, NRCS, Washington, DC, 1995).

Figure 4.6 U.S. Cropland Erosion by Type, 1982-1992



Source: See Part III, Table 7.6.

chase easements on 117,000 acres of farmland. Pennsylvania has spent more than $150 million to protect almost 75,000 acres. Massachusetts and New Jersey also have made substantial investments in the program.

The federal government is supporting farmland protection; a provision in the 1996 farm bill authorizes a farmland protection program with up to $35 million in funding. The program is designed to help state programs purchase conservation easements.

Reducing Soil Erosion

Since the Dust Bowl days of the 1930s, and particularly over the last two decades, American farmers have made remarkable progress in reducing soil erosion on cropland and rangeland. In 1982, erosive forces moved about 3.1 billion tons of cropland soil, including about 1.4 billion tons attributable to wind erosion and 1.7 billion tons carried away by water. By 1992, soil erosion on cropland had dropped to about 2.1 billion tons, including 900 million tons via wind and 1.2 billion tons via water (Figure 4.6).

Depending on soil type and a number of other factors, some soil erosion is tolerable. Over the 1982-92 period, cropland with tolerable levels of sheet and rill erosion increased from 73 to nearly 79 percent of all cropland, while tolerable rates for wind erosion increased from 79 to nearly 84 percent. Nevertheless, erosion remains above tolerable rates for a substantial fraction of the nation's cropland (Figures 4.7 and 4.8).

Taking highly erodible land out of production has helped reduce erosion tremendously. Under the Conservation Reserve Program, which has taken 36 million acres of highly erodible land out of production, farmers planted trees and grasses, installed windbreaks and wildlife ponds, and used a variety of other conservation practices. The CRP reduced erosion on retired acres from 12.5 tons per

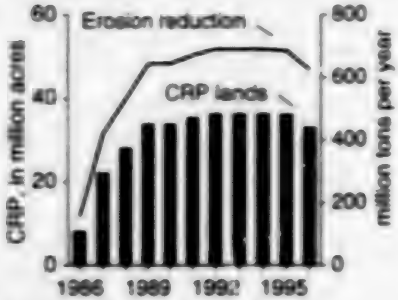
Figure 4.7 Soil Erosion as a Proportion of the Tolerable Rate (T), 1982

Source: USDA/NRCS National Resources Inventory #RWH 1570, 1982

Figure 4.8 Soil Erosion as a Proportion of the Tolerable Rate (T), 1992

Source: USDA/NRCS National Resources Inventory #RWH 1571, 1992

Figure 4.9 Erosion Reduction on Lands in the Conservation Reserve Program, 1986-1996



Source: USDA, Economic Research Service.
Note: Erosion reduction refers to the amount of soil not eroded due to CRP. Data are based on cumulative enrollment at the end of each calendar year.

acre in 1982 to 1.5 tons per acre in 1992. Total annual soil erosion reduction as a result of the CRP may be as much as 700 million tons (Figure 4.9). Furthermore, wildlife populations rebounded in many areas as grassland and forest habitat increased.

New farming practices also are helping reduce erosion. Conservation tillage, which reduces soil disturbance and maintains residue levels of at least 30 percent on a field surface, can both reduce soil erosion and increase soil organic matter. Over the 1989-96 period, conservation tillage on cropland increased 45 percent, from 71.7 to 103.8 million acres. Conservation tillage acres are concentrated in the Midwest and Northern Plains, the only regions where the practice is undertaken on more acres than conventional or reduced tillage (Figure 4.10).

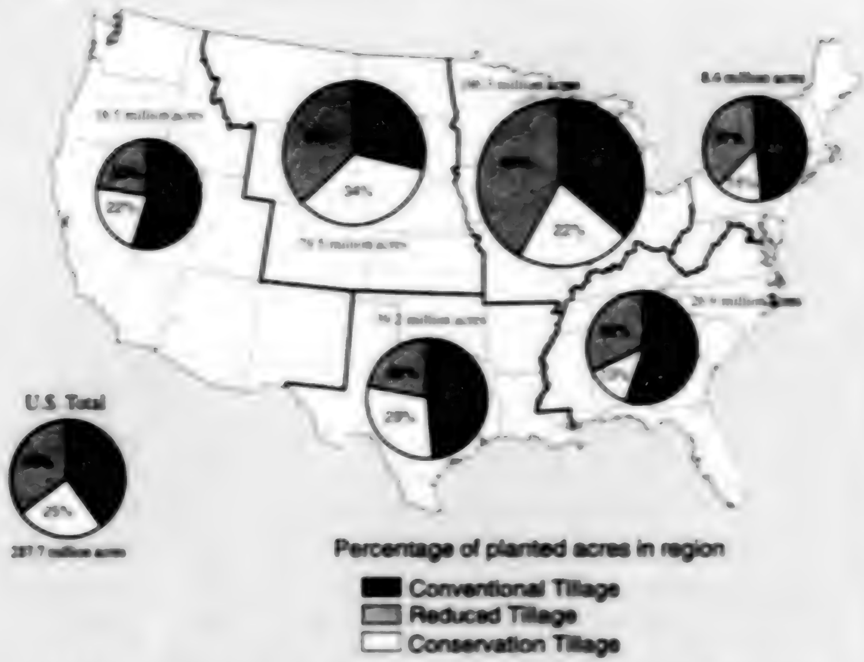
Conservation compliance plans, in which farmers plan and apply conservation systems to highly erodible cropland as a condition of eligibility for USDA farm benefit programs, have been developed on more than 140 million acres of cropland since the late 1980s. Implementation of these plans reduced the average annual soil loss on these acres from 11.7 to 6.9 tons per acre between 1992 and 1995. By 1992, erosion on about 42 million acres—almost 40 percent of all highly erodible cropland—had been reduced to below the tolerable level.

Is there a payoff to such conservation initiatives? In the Driftless Area of the Upper Mississippi Valley, including Coon Valley, Wisconsin, USDA started a program of conservation initiatives as early as 1933. At the time the project was established, it was estimated that soil erosion was nearly 15 tons per acre. In 1992, some 60 years later, the average annual erosion rate had declined to just over 6 tons per acre. This occurred even though the acreage in row crops, which is expected to have high erosion rates, had nearly doubled, while the acreage in small grains, which normally has lower erosion rates, had declined more than 80 percent.

Protecting and Restoring Wetlands

The conversion of wetlands to croplands has historically been one of the principal factors in the rapid loss of wetlands in the United States. Although wetlands in the conterminous United States are continuing to diminish, the rate of decline has slowed substantially.

Figure 4.10 U.S. Tillage Practices by Region, 1995



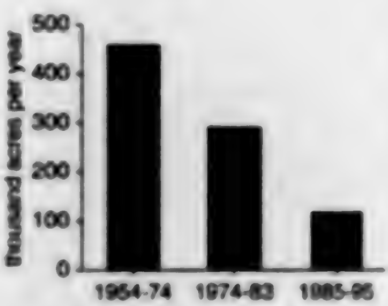
Source: U.S. Department of Agriculture, Natural Resources Conservation Service, based on Conservation Technology Information Center data, 1995.

Note: U.S. pie chart is not on same scale as regional pies.

There are now about 100.9 million acres of wetlands in the conterminous United States. Of this total, 95 percent are inland freshwater wetlands, while 5 percent are coastal or estuarine wetlands. Freshwater forested wetlands make up the single largest category.

According to the latest Interior Department estimates on trends in wetland losses, the average annual net loss of wetland area between 1985 and 1995 was 117,000 acres, or a total of about 1.2 million acres over the entire period. This is some 60 percent lower than the loss rate reported for the period between the mid-1970s and the mid-1980s (Figure 4.11).

Figure 4.11 Average Annual Rate of U.S. Wetlands Losses, 1950s to 1990s



Source: See Part III, Table 6.14.

The latest figures indicate a decline of almost 5 percent in forested wetlands since 1985. As forested wetlands are cleared, some of these wetlands are replanted to trees or allowed to revegetate and remain as wetlands. The net result is a change from one wetland type to another; for example, the wetland shrub category increased in area in the 1985-95 period, but this was mostly at the expense of forested wetlands.

Wetland restoration activities that convert uplands to wetlands are contributing an estimated 78,000 acres per year to the wetlands total. An estimated 150,000 acres of freshwater emergent marshes were restored or created on agricultural lands during this period, according to the Interior Department.

The Policy Response. The federal government has used a combination of carrots and sticks to slow the rate of wetlands losses and encourage restoration of wetlands wherever possible.

Farmers who own or manage wetlands are directly affected by two federal programs. Section 404 of the Clean Water Act requires individuals to obtain a permit before discharging dredged or fill material into waters of the United States, including most wetlands. The Swampbuster provisions of the Food Security Act withhold certain federal farm benefits from farmers who convert or modify wetlands.

Most routine ongoing farming activities do not require section 404 permits. Other farming activities that involve discharges of dredged or fill materials may not require a section 404 permit if the activity is part of an ongoing farming operation and cannot be associated with bringing a wetland into agricultural production or converting an agricultural wetland to a non-wetland area.

The Swampbuster program generally allows the continuation of most farming practices. The program discourages farmers from altering wetlands by withholding federal farm program benefits from any person who plants an agricultural commodity on a converted wetland that was converted by drainage, dredging, leveling, or any other means (after December 23, 1985), or converts a wetland for the purpose of or to make agricultural commodity production possible (after November 28, 1990).

Federal efforts to protect wetlands have proven quite controversial over the years. Since coming into office, the Clinton Administration has developed a 40-point program to enhance wetlands protection while making wetlands regulation more fair and flexible. Since the program was announced in August 1993, many proposals have been implemented – streamlining the wetlands permitting program, encouraging mitigation of wetland impacts through the permitting process, responding to the concerns of farmers and small landowners, improving cooperation with private landowners to protect and restore wetlands, and increasing the role of state, local, and tribal governments in wetlands protection.

To make the wetlands program more consistent and predictable for farmers, the Clinton Administration clarified that "prior converted croplands" are not subject to regulation under section 404. Nearly 53 million acres are covered by

this action, which exempts lands that no longer perform the wetlands functions as they did in their natural condition.

For those farmers with wetlands on their property, the Administration has simplified the process by using a single wetlands determination by the Department of Agriculture for both Food Security Act and Clean Water Act programs.

In 1995, an approval process was set up that allows landowners to affect up to one half acre of non-tidal wetlands for construction of single-family homes without applying for an individual section 404 permit.

Wetlands Reserve Program. Numerous programs encourage restoration of wetlands. One of the most successful is USDA's Wetlands Reserve Program, a voluntary program that offers landowners a strong financial incentive to restore and protect wetlands.

The program gives landowners three options: a permanent easement, in which USDA will pay up to the agricultural value of the land and all the costs of restoring the wetlands and uplands, a 30-year easement, in which USDA will pay 75 percent of what would be paid for a permanent easement and 75 percent of the restoration costs, and a restoration cost-share agreement, in which USDA will pay 75 percent of the cost of restoring a wetland in exchange for a minimum 10-year agreement to maintain the restoration. The 1996 farm bill requires that one third of the acres be enrolled though the use of permanent easements, one third through 30-year easements, and one third through restoration cost-share agreements, to the extent practicable. To date, demand and interest in permanent easements has been much higher than in the other two options.

Any type of land that can be restored to a valuable wetland at a reasonable cost is eligible, except for wetlands drained in violation of the Swampbuster program or land converted to trees under the Conservation Reserve Program.

In response to the devastating floods in the Midwest in 1993, an Emergency Wetlands Reserve Program was started that offered landowners an alternative to agriculture on their floodprone lands. In 1994 and 1995, over 86,000 acres were enrolled in this program.

All told, both programs have enjoyed strong support by both farmers and conservationists. Since 1992, at least 400,000 acres of restorable wetlands and adjacent upland were enrolled in both the Wetlands Reserve Program (WRP) and the Emergency Wetlands Reserve Program (EWRP).

Iowa River Corridors Project. In Iowa, the Emergency Wetlands Reserve Program has been instrumental in building a broader locally driven program to rationalize land uses along the state's river corridors.

During the discussions that took place after the devastating 1993 flood, many Iowans had ideas about what should take place on their lands beyond returning flood-prone lands to wetlands. There was strong local interest in making the best use of all land along the river, uplands as well as flood-prone bottomlands. This could include recreation, non-consumptive wildlife uses, alternative crops, changed

management of forest and grasslands, and traditional row crop production.

Largely through the active involvement of local groups, 11 river corridor projects are now underway in Iowa. Many groups are taking an active role in the river corridor projects, providing funds, technical support, contacting landowners, providing assistance for enhancement, and much more. The Iowa Natural Heritage Foundation's attorney works essentially full-time on WRP/EWRP river corridors. Many other organizations—the Fish and Wildlife Service, Iowa Department of Natural Resources, county conservation boards, Iowa Natural Heritage Foundation, and Nature Conservancy—are providing funds to purchase easements. Local groups such as Pheasants Forever and Ducks Unlimited are often involved in these river corridor projects.

IMPROVING WATER MANAGEMENT

Conflicts over current and future allocations of surface water are an especially difficult challenge in the western states. Typically, such conflicts are between the historical use of water for agricultural use by farmers on the one hand, and the increasingly recognized needs for urban and environmental uses on the other.

Fish and wildlife species that depend on river ecosystems for their survival are declining in every major river basin in the West. Some 184 species—either threatened, endangered, or proposed for listing under the Endangered Species Act—are affected by the Bureau of Reclamation's operations. In addition, the water rights of many Native American tribes have yet to be quantified or allocated.

Since rising costs and other considerations now preclude construction of major new water supply projects in the West, new demands for water have to be met largely by reallocating water from existing uses, primarily agriculture.

In response, the Bureau of Reclamation has identified a variety of water management measures: fundamental measures, such as pricing and measurement systems; institutional measures, such as water shortage contingency plans; operational measures, such as distribution control; and facilities-related measures, such as water reuse systems.

Fundamental measures include: a) improved water measurement, which should accommodate some form of volumetric pricing and billing for individual users and allow for tracking of water deliveries to individual users in order to accommodate a billing system based on deliveries; b) changes in water pricing to provide a stronger incentive for efficient water use; c) educational programs, which can help make water users aware of the benefits of water-use efficiency; and d) designating a conservation coordinator, which provides an important focal point for district water users.

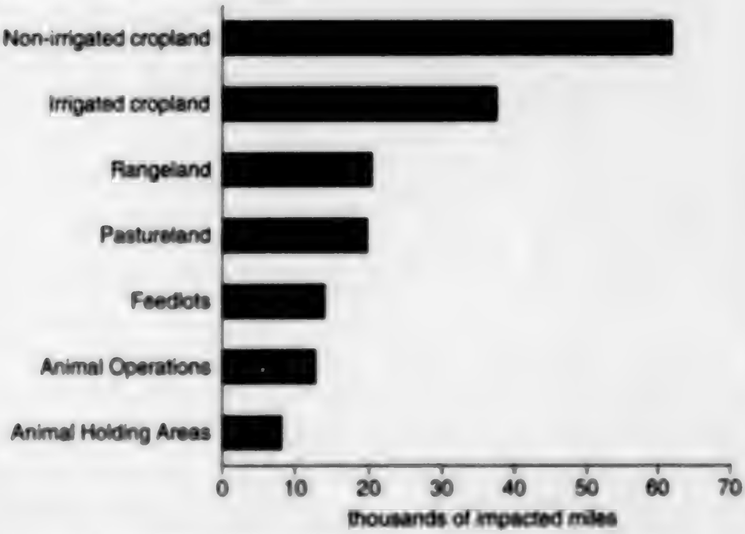
Institutional water management measures include: a) water shortage contingency plans, which provide farmers with fairly certain information as to what they can expect in terms of water deliveries during drought periods; b) on-farm con-

servation incentives, such as tax incentives or low interest loans for improvements such as ditch lining, development of water reuse systems, installation of surge valves and gated pipes, sprinkler systems, field leveling, or soil treatments; c) water transfers, including permanent transfers, contingent transfers, tradeable shares or allotments, water banking, water wheeling, or transfers of reclaimed, conserved or surplus water; and d) land management, including land retirement, fallowing, or conversion to dryland farming.

Operational water management measures include: a) improved operating procedures, such as changes to a district's operating procedures that provide for increased delivery and storage flexibility; b) distribution control, such as installation of new structures or improvements to existing structures to more precisely manipulate flow rates and head levels; c) system-wide irrigation scheduling, which attempts to schedule water deliveries to match irrigation requirements; d) on-farm irrigation scheduling, such as using evapotranspiration estimates and soil moisture to provide a better estimate of true crop needs; and e) conjunctive use, which refers to the coordinated operation of surface water and groundwater resources to meet water requirements.

Facilities-related water management measures include: a) construction of regulatory reservoirs, which can help a district better match water deliveries to crop requirements; b) lining of canals and reservoirs, which can provide substantial

Figure 4.12 Agricultural Sources of Pollution in Surveyed U.S. Rivers and Streams, 1996



Source: U.S. Environmental Protection Agency, *National Water Quality Inventory: 1996 Report to Congress*, Table A4 (EPA, Washington, DC, 1998).

reductions in seepage losses; and c) water re-use systems, which are designed to capture system spills, seepage, and drainage waters for immediate or later use.

IMPROVING WATER QUALITY

Agriculture remains a vexing and significant source of pollution in rivers and lakes. According to the Environmental Protection Agency's 1996 National Water Quality Inventory, which assessed 19 percent of the nation's river and stream miles and 40 percent of lakes and ponds, agriculture is the most widespread source of pollution in the nation's waterways. Farms and ranches generate pollutants that degrade aquatic life or interfere with public use of 25 percent of all river miles surveyed. That is, agriculture is a source of pollution in one of every four surveyed river miles, whereas the next leading sources—municipal point sources and hydrologic modifications/habitat alteration—are problems in less than one in every 20 surveyed miles. Agriculture also is the leading source of impairment in lakes, affecting about 19 percent of surveyed lake acres.

The states reported that nonirrigated crop production impaired the most river miles, followed by irrigated crop production, rangeland, pastureland, feedlots (facilities where animals are fattened and confined at high densities), animal operations (facilities other than large cattle operations—primarily poultry or swine), and animal holding areas (facilities where animals are confined briefly before slaughter) (Figure 4.12).

Nutrients—mainly nitrogen and phosphorus—are vital in the promotion of plant growth; if applied inappropriately or excessively, however, they are likely to move from the land into the water. Nitrate nitrogen is highly mobile; it can leach into groundwater, volatilize into the atmosphere, or be carried overland to nearby surface waters (Figure 4.13). Phosphate, while not as mobile as nitrate, tends to be carried on soil particles that erode off farmers' fields (Figure 4.14). When phosphorus reaches a saturation point in the soil it will also move freely in solution. Nitrate concentrations in streams and groundwater tend to be higher in agricultural areas than in undeveloped or urban areas (Figure 4.15). Phosphorus concentrations, on the other hand, tend to be higher downstream from urban sources because of point source contributions (Figure 4.16). See also Chapter Five, The Urban River.

Nitrogen and phosphorus interact with soils in different ways and numerous natural and manmade factors affect their potential transport and fate, including climate, soil type, proximity to water courses, tillage and conservation practices, and application rates and timing, among others.

Agriculture accounts for about 80 percent of all pesticide use. Some crops, such as corn and cotton, are pesticide-intensive, while others such as wheat are not. Pesticides can leach through the soil into groundwater or run off the fields and into nearby water bodies. Runoff potential is somewhat greater in the Midwest (Figure 4.17), while leaching potential is greater in the humid Southeast (Figure 4.18).

Figure 4.13 Potential Nitrogen Fertilizer Loss from Farm fields, 1992

Source: USDA/NRCS National Resources Inventory #SMW 1554, 1992

Figure 4.14 Potential Phosphate Fertilizer Loss from Farm fields, 1992

Source: USDA/NRCS National Resources Inventory #SMW 1555, 1992

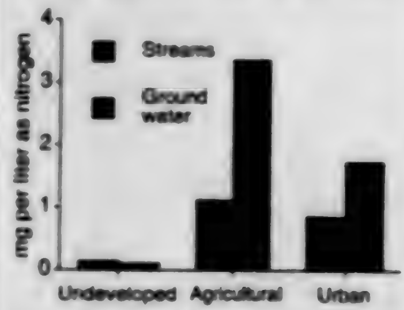
According to U.S. Geological Survey findings, the factors most strongly linked with increased likelihood of pesticide occurrence in wells are high pesticide use, high recharge, and shallow, inadequately sealed, or older wells. Frequencies of pesticide detection are almost always low in low-use areas, but vary widely in areas of high use. While pesticides are commonly present in low concentrations in groundwater beneath agricultural areas, they seldom are at levels exceeding water-quality standards. Low rates of pesticide detection often are found in high-use areas, indicating that other hydrogeoloic factors affect their occurrence in groundwater.

The frequency of pesticide detection may also be substantial in nonagricultural areas. In the Georgia portion of the Apalachicola-Chattahoochee-Flint River basin, pesticides applied to lawns, golf courses, parks, roadsides, swimming pools, and residential structures occur in urban watersheds. Concentrations of these compounds tend to be higher and are found for a greater part of the year than in agricultural watersheds.

An Emerging Problem: Animal Waste Pollution

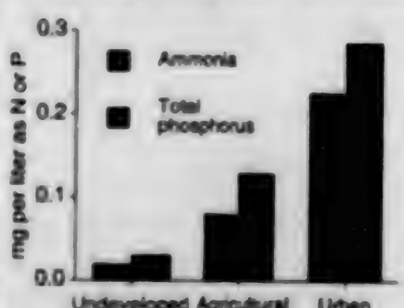
The production of broilers, turkeys, hogs, and non-dairy cattle is increasingly taking place in concentrated spaces with little cropland, raising serious concerns about the increasing risk of water pollution from animal waste spills, runoff from farm fields, and leakage from waste storage facilities. Animal waste pollution has been implicated as one of the causes of recent deadly outbreaks of the microorganism *Pfiesteria piscicida*.

Figure 4.15 Nitrate Concentrations in Streams and Ground Water by Land Use, 1979-1990



Source: Mueller, D.K. & D.R. Helsel, *Nutrients in the Nation's Waters – Too Much of a Good Thing?* USGS Circular 1136 (USGS, Reston, VA, 1996).
Note: Data are median concentrations compiled from stations at the first 20 study units in the National Water Quality Assessment (NAWQA) Program.

Figure 4.16 Ammonia and Total Phosphorus Concentrations in Streams by Land Use, 1979-1990



Source: Mueller, D.K. & D.R. Helsel, *Nutrients in the Nation's Waters – Too Much of a Good Thing?* USGS Circular 1136 (USGS, Reston, VA, 1996).
Note: Data are median concentrations compiled from stations at the first 20 study units in the National Water Quality Assessment (NAWQA) Program.

Figure 4.17 Pesticide Runoff Potential for Field Crop Production, 1992

Source: USDA/NRCS National Resources Inventory #SMW 1082, 1992

Figure 4.18 Pesticide Leaching Potential for Field Crop Production, 1992

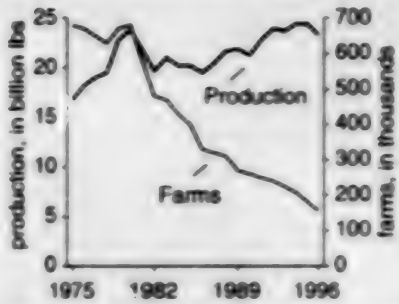
Source: USDA/NRCS National Resources Inventory #SMW 1083, 1992

The transition to more intensive livestock and poultry operations is quite dramatic. Over the past 15 years, the number of hog farms has dropped from about 600,000 to 157,000, yet the nation's hog inventory has increased (Figure 4.19). The number of farms with broiler houses dropped by 35 percent between 1969 and 1992, but over the same period broiler production nearly tripled (Figure 4.20).

Of the nation's 450,000 confined feedlot operations, just 6,600 – only about 1.5 percent – account for about 35 percent of total U.S. livestock production. Just 3 percent of the nation's hog farms produce more than 50 percent of the nation's hogs, while 2 percent of cattle feed operations account for over 40 percent of all cattle sold.

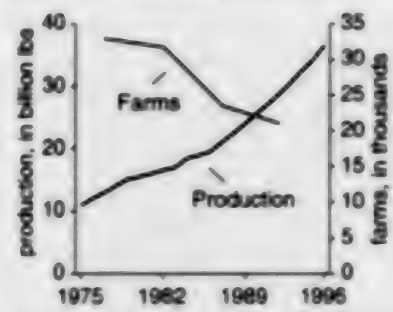
These operations are producing vast amounts of animal waste. Estimated annual U.S. manure production from animals totaled about 1.37 billion tons in 1997, or about 5 tons for every person in the nation. On the Delmarva Peninsula east of the Chesapeake Bay, 600 million chickens produce over 1.6 million tons of waste every year and as much nitrogen as from a city of 500,000 people.

Figure 4.19 U.S. Hog Farms and Pork Production, 1975-1996



Source: USDA, NASS, Agricultural Statistics (annual)

Figure 4.20 U.S. Broiler Farms and Production, 1975-1996



Source: USDA, NASS, Agricultural Statistics (annual) and Census of Agricultural (quinquennial)

The rising volume of animal waste is raising the risk of environmental impacts. Hogs and cattle generate liquid and solid waste. Water is used to flush this waste, typically into earthen lagoons or slurry tanks. Most of the solids (including much of the phosphorus) settle into a sludge at the bottom; most of the nitrogen remains dissolved in the water or volatilizes into the atmosphere. Poultry operations typically produce a dry litter with about 15-25 percent moisture content that is stacked or stored in metal or wooden structures or on the ground.

Animal waste, when applied in amounts greater than can be used by crops or retained by the soil, is susceptible to leaching and run-off into surface and groundwater. Waste spills from storage facilities also are a problem. An informal survey in a few livestock-producing states indicates that spills roughly doubled between 1992 and 1996. In North Carolina in 1995, 35 million gallons of

animal waste spilled into the state's waterways.

In areas with a large concentration of intensive livestock operations, many indicators of water quality are worsening. At one sampling site on the Neuse River in North Carolina, for example, average concentrations of nitrogen-bearing compounds and ammonia nitrogen doubled from the 1954-60 to the 1991-95 periods. Poultry and livestock operations may account for more than one third of the nitrogen that enters the Neuse River.

Pfiesteria seem to thrive in nutrient-enriched brackish waters such as the Neuse estuary, where the salt content is about 12 to 14 parts per thousand. In 1991, over one billion fish – mostly menhaden – died during a *Pfiesteria* attack in September and October. Another large fish kill occurred in August through November 1995.

Pfiesteria outbreaks occurred in Maryland's Pocomoke River in 1996 and again in 1997. During the October 1996 period of the attack, total nitrogen levels were at 10-year highs and salinity was at a 10-year low. Nitrogen and phosphorus levels in the Pocomoke River are higher than average when compared to other Chesapeake Bay tributaries, and nitrogen levels have been increasing since 1986. In August 1997, another *Pfiesteria* attack killed an estimated 30,000 fish, again mostly menhaden.

Maryland was the first state in the nation to link toxic outbreaks of *Pfiesteria* to concerns about public health. Symptoms reported among people with close exposure to *Pfiesteria* in its toxic form include memory loss, respiratory problems, and skin rashes. (See Chapter Six.)

Current Federal and State Actions. Under the Clean Water Act, no point source may discharge pollutants unless it is in accordance with a permit issued by EPA or a state under EPA's National Pollutant Discharge Elimination System (NPDES). The act's definition of point source includes concentrated animal feeding operations (CAFOs). EPA's regulations define a CAFO as an animal feeding facility in which animals are confined for 45 days or more out of a 12-month period, over which no crops or forage growth is sustained, and that meets one of the following additional conditions: a) it contains 1,000 animals units and has the potential to discharge pollutants into water by any means; b) it contains over 300 animal units and is discharging pollutants through a man-made device directly into a water body; or c) it is designated a CAFO after a site inspection determines that the operation is or has the potential to be a significant polluter, no matter its size.

Under the Safe Drinking Water Act, animal feeding operations that are identified as a source of groundwater contamination, or are within a designated wellhead protection area, or that are located near public water systems, may be subject to additional discharge limitations or management practices.

The Department of Agriculture does not have regulations that govern animal waste management. The Natural Resources Conservation Service provides conservation assistance to farmers that

includes waste and nutrient management for livestock and poultry farms.

Many states have enacted new laws and regulations recently. For example, North Carolina and Kentucky recently imposed moratoria on the construction of most new livestock operations.

At the federal level, the Clinton Administration's new Clean Water Action Plan includes a commitment that EPA and USDA will jointly develop a unified national strategy to minimize the environmental and public health impacts of animal feeding operations. EPA is considering new Clean Water Act regulations, increased inspections of operations, and stepped-up enforcement against polluting operations. USDA and EPA are planning to establish comprehensive management systems for animal feeding operations that are environmentally sustainable.

The National Environmental Dialogue on Pork Production – which includes EPA, USDA, several state environmental and agriculture departments, and individual pork producers affiliated with the National Pork Producers Council – has recommended environmental regulations for swine operations. These recommendations will: apply to all sizes of operations, require new operations to comply with recognized engineering standards, limit manure application by crop nutrient needs and soil nutrient levels, require certification and training for facility operators, require setbacks from water bodies, residences, and other public facilities, and allow public notice and comment on proposed operations.

New Strategies for Better Water Quality

Better management practices are having a demonstrable effect in reducing agricultural pollution. Such practices include:

- Maintaining unplowed strips of grass and vegetation or natural wetland areas along stream banks to prevent soil and water runoff.
- Accurately determining fertilizer needs.
- Ensuring the efficient use and careful application of pesticides.
- Using practices such as crop rotation that interrupt destructive insects' life cycles to reduce the need for pesticides.

Over 100 different beneficial practices have been identified. The most widely adopted include conservation cropping, cover or green manure crops, conservation tillage, and animal manure management. Popular management practices include improved fertilizer timing and application and use of soil nitrogen tests.

In a demonstration project in Delaware, farmers adopted nutrient management practices on 44,000 acres, reducing nitrogen applications by 2,600 tons and phosphorus applications by 2,100 tons. In a survey of 16 demonstration projects in the early 1990s, USDA found that annual nitrogen application rates declined by 14 to 129 pounds per acre, while phosphorus applications were reduced by 3 to 106 pounds per acre. As of 1994, total annual reductions for the

Aerial spraying of North Carolina cornfields

Photo Credit
S.C. Delaney/EPA

16 projects were 22.3 million pounds of nitrogen and 10.3 million pounds of phosphorus.

The Maumee River Basin, Ohio Between 1972 and 1982, phosphorus loadings into Lake Erie from municipal sources were reduced by 85 percent, and it was clear that further reductions in phosphorus would have to come from nonpoint sources such as agriculture.

Ohio's Maumee River was a prime candidate for such an initiative, since it was contributing about 46 percent of the phosphorus and 37 percent of sediment entering Lake Erie, while providing only 3 percent of the inflow. Cropland covers about 80 percent of the basin's 3.1 million acres.

Studies indicated that land use practices such as conservation tillage and winter cover residue had the best potential to reduce sediment and phosphorus runoff. State and federal officials settled on a strategy that emphasized lowering the cost a farmer pays for farm equipment that leaves more plant residue on the surface. In October 1991, the strategy was approved by EPA and awarded a $641,000 grant under section 319 of the Clean Water Act. The plan included targeting critical areas, listing residue enhancing equipment and land treatments approved for cost share, maximum cost-share amounts, and minimum acreage requirements for each cost-share item.

Soil and water conservation districts were permitted to approve or disapprove applications from local farmers, while a joint advisory board consisting of one representative from each county in the basin provided local input and direction. In the first year, some 513 farmers from 15 counties participated, committing an average of $10,000 each in pollution control equipment. The $641,000 in cost-share payments generated some $5 million in matching funds.

West Lake, Iowa. West Lake, the surface reservoir for the cities of Osceola and Woodburn in south-central Iowa, was in the late 1980s heavily polluted with sediment, pesticides, and nutrients. About two thirds of the lake's drainage area was cropland, primarily in a corn-soybean rotation.

Sediment was rapidly reducing the reservoir's capacity, damaging filtration and pumping equipment, increasing maintenance costs, and making additional water treatment necessary. In 1987, sampling by the Osceola water treatment plant detected atrazine and cyanazine levels above the federal drinking water standards; concentrations remained high in 1991.

In November 1990, the Clarke County Soil and Water Conservation District developed a watershed management plan that was supported by an EPA grant and funds from Iowa's Resource Enhancement and Protection Program. Under the plan, 41 landowners representing 2,500 acres of the most highly erodible cropland were offered incentives. They included financial payment for acres contracted into soil conserving practices, soil fertility analysis, sprayer calibration, evaluation of land use, assistance in implementing reduced or no-till systems, and fertility and crop pest consultation.

In 1991, project staff convinced a number of farmers to voluntarily reduce or eliminate their use of atrazine and cyanazine. For the farmers cooperating in this voluntary program, the number of gallons of atrazine applied dropped from 443 in 1991 to 8 in 1992. For the entire watershed, the use of atrazine was nearly cut in half, going from 1,159 gallons in 1991 to 638 gallons in 1992; cyanazine use dropped from 3,281 gallons in 1991 to 2,500 in 1992. Lake monitoring also showed that cyanazine and atrazine levels dropped substantially in 1992. According to participating farmers, voluntary compliance was quicker and more effective than waiting for mandatory regulatory compliance. The limited number of landowners and the relatively small size of the watershed also were factors in the program's success.

The project's integrated crop management component also provided recommendations for alternative solutions to atrazine use, including services such as soil tests and recommendations for managing pest outbreaks.

In 1992, the integrated crop management program designed a nutrient management strategy for 689 acres that resulted in substantial reductions in fertilizer. Reduced applications of phosphorus and potassium saved one farmer $18 per acre on 87 acres and another saved $13 per acre on 190 acres.

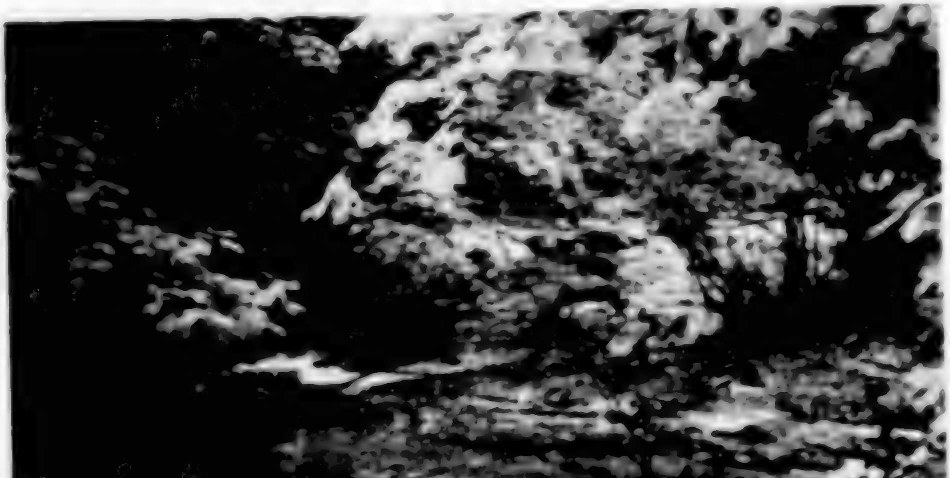
The project also resulted in a significant decrease in soil loss. In 1990, soil

loss averaged 18.8 tons per acre; two years later, it was down to 7.5 tons per acre. Much of the reduction was due to the widespread adoption of no-till planting, terraces and sediment control structures, field borders, waterways, buffer strips, and cross-slope farming – all promoted through the project.

Central Platte Valley, Nebraska. Farmers in the Central Platte Valley in Nebraska have been using heavy doses of nitrogen fertilizers and intensive irrigation since the 1960s, largely for the production of corn. Combined with the area's coarse sandy soils and shallow water table, these practices led to significant nitrate contamination in groundwater. In some parts of the region, nitrate-nitrogen groundwater concentrations were reaching 18.9 parts per million – nearly twice the safe level of 10 ppm established by EPA – and in a few sites concentrations were as high as 40 ppm. Since groundwater provided essentially all the area drinking water, these levels of nitrate contamination posed a serious threat to the area's drinking water supplies.

In response to the problem and the mandates required by a 1986 state groundwater protection law, the Central Platte Natural Resources District in 1987 developed a comprehensive groundwater management plan. The plan – the first in the state designed to reduce nitrate contamination in groundwater – tailored its management directives according to the severity of the contamination problem.

In Phase I areas, with contamination in the 9-12.5 ppm range, producers were



A stream in rural Michigan

Photo Credit: Greg Baier/USGS

banned from applying nitrogen on sandy soils in fall and winter and were required to attend training classes to become certified to apply nitrogen fertilizers. In Phase II areas, with contamination in the 12.6-20 ppm range, producers must be certified, test soils and irrigation water annually for nitrate-nitrogen content, and file annual management reports. They are also prohibited from applying nitrogen to sandy soils in fall and winter. Compliance with recommended practices for nitrogen and irrigation water management is voluntary. In Phase III areas, with concentrations exceeding 20 ppm, producers must meet all Phase II requirements, are prohibited from applying nitrogen in fall and winter on all soil types, and must split spring applications of nitrogen or include an inhibitor.

Nitrate-nitrogen levels in groundwater, which had been increasing at an average rate of 0.5 ppm per year since 1960, began declining in 1989 at an average rate of more than 0.3 ppm per year. An average decline of more than 1.0 ppm was achieved in three years. Concentrations leveled off in 1991-92, apparently as a result of excessive leaching of nitrate-nitrogen due to unusually wet conditions.

An important part of the program's success was an education effort to convince farmers that the recommended nitroge[illegible] irrigation practices would not h[illegible] their yield and would save money in the long run. In 1992, district farmers saved approximately $1.6 million by applying less fertilizer and still maintained acceptable levels of crop yields.

PROTECTING RIVER BANKS

The many opportunities for farmers to reduce nonpoint pollution through better management practices represent an important component of a broad effort to protect America's rivers. Another vital part of this effort is the protection and restoration of streambanks and the "riparian" lands adjacent to creeks, streams, and rivers.

In the Eastern half of the nation, streamside woodlands can play a vital role in reducing runoff of nutrients and sediment, in ameliorating the effects of some pesticides, and in improving food and habitat conditions for stream communities. For example, sediment is reduced by the many obstructions encountered in a forest; additional sediment is filtered out by the porous soil structure, vegetation, and organic litter.

Since about 85 percent of available phosphorus is bonded to the small soil particles that comprise sediment, phosphorus is also reduced by the filtering action of the streamside forest. Roughly 4 percent of the phosphorus is attached to soil particles that are too small to be filtered by these processes.

Nitrogen from fertilizer and animal waste is soluble in water as nitrate and can leach downward through the soil into groundwater or move laterally to contaminate surface waters. Under well-oxygenated soil conditions, bacteria and fungi in the streamside woodlands convert nitrogen in runoff and decaying organic debris into mineral forms (NO_3), which can be synthesized into proteins by plants or bacteria. When soil moisture

is high, denitrifying bacteria convert dissolved nitrogen into various nitrogen gases, which are then returned to the atmosphere.

Pesticide residues borne by runoff can also be converted to non-toxic compounds by microbial decomposition, oxidation, reduction, hydrolysis, solar radiation, and other biodegrading forces at work in the soil and litter of the streamside woodlands.

Streamside woodlands play an important role in maintaining the health of aquatic ecosystems. In small, well-shaded upland streams, as much as 75 percent of the organic food base may be supplied by dissolved organic compounds or detritus such as fruit, limbs, leaves, and insects that fall from the forest canopy. The stream-bottom bacteria, fungi, and invertebrates that feed on this detritus form the basis of the aquatic food chain, and in turn they pass on this energy to larger fauna and eventually to fish.

Through their impact on water temperature, streamside woodlands also play an important role in improving rivers as habitat for trout and other fish. Lacking shade from a forest, stream water temperatures are dramatically increased by direct solar radiation, which has the double effect of decreasing the amount of dissolved oxygen in the water and increasing a trout's demand for oxygen. Furthermore, insects, the favorite food of trout, are abundant in stream reaches cooled by streamside forests.

Though comprising less than 1 percent of the region's total area, riparian areas in the West are nevertheless among the region's most productive and valuable lands.

These areas provide important habitat for many western wildlife species. In the Great Basin of southeastern Oregon, more than 75 percent of terrestrial wildlife species are dependent upon or use riparian habitats. In Arizona and New Mexico, 80 percent of all vertebrates depend on riparian areas for at least half of their life cycles. More than half of all bird species in the southwestern U.S. are completely dependent upon riparian areas.

By the late 1880s, about 19 million cattle and sheep were grazing in the arid West. The rapid expansion of livestock operations in the West took a heavy toll on many western riparian areas. Livestock tend to concentrate in riparian areas for extended periods of time, eat virtually all of the grassy and woody vegetation, and trample the streambanks while using the stream for drinking water. Over several decades, native perennial grasses were virtually eliminated from vast areas and were replaced by sagebrush, mesquite, juniper, and other exotic plants.

As rangelands deteriorated, wind and water erosion accelerated. Unchecked flood flows eroded unprotected streambanks and cut down streambeds. Water tables lowered, and perennial streams became intermittent or dry during much of the year. These conditions led to a drying out of the land that reduced the productivity of an estimated 225 million acres in the West.

Today, many streams throughout the West are littered with the remains of what

were once vigorous aspen groves. Aspen reproduce by sending up shoots from roots, but if these young plants are constantly grazed, the parent trees will eventually die and aspens will disappear from the site.

Can Western riparian areas be successfully restored? A June 1988 report by the General Accounting Office (GAO) reviewed 22 riparian areas in 10 Western states that had been restored by the Bureau of Land Management or the Forest Service. GAO found that these successes — while limited in number compared to the scope of the problem — "demonstrate dramatically the extent of improvement that is possible." Furthermore, the report found no technical barriers to improving riparian areas and that the restoration approaches used on successful projects can essentially be applied to all riparian areas on federal rangelands.

GAO found that all these projects shared one technique in common — limiting the access of livestock to riparian areas. In some cases, the area was fenced off; in others, the number of livestock was limited or their grazing was restricted to certain periods of the year.

In some cases, improvements also were made in areas away from the streams in the uplands in order to provide water for livestock, lessen grazing pressure on the riparian areas, and improve the water runoff into streams. Some of these improvements included building water storage tanks and troughs with water piped to them from the stream or a spring, blasting potholes to collect water, burning unwanted vegetation to encourage growth of grass, and making improvements to springs to increase their flow. In each case, restoration depended primarily on managing livestock so that the native vegetation had more opportunity to grow and regenerate.

Since about 1980, the overall condition of western rangeland has stabilized and in some areas improved. But riparian areas, which are now widely recognized as crucial to the overall health of the range, remain largely in degraded condition.

Duck Creek/Henry's Lake, Idaho

Henry's Lake covers about 6,500 acres along the continental divide in eastern Idaho. The lake is fed by numerous large springs; several small tributary streams provide spawning habitat for cutthroat and brook trout. Juvenile fish migrate to the lake and attract anglers from around the United States. Over many decades, livestock had depleted streamside vegetation and trampled streambanks; summer water temperatures had increased, streambanks had eroded, and trout spawning gravels had been smothered in sediment.

To deal with the problem, concerned fishermen, summer home owners, local ranchers and business owners formed the Henry's Lake Foundation to raise money and manpower to revitalize the lake fishery and the dependent local economy. For its first project in 1985, the foundation raised money from its members to permanently exclude livestock from the riparian area along a half-mile reach of private land on Duck Creek, an important trout spawning and rearing stream that feeds into Henry's Lake. Foundation members took time off from jobs and

vacations to build a fence to the landowner's specifications. The foundation paid the landowner a small fee to cover the cost of maintaining the fence.

Even after decades of grazing, the area fenced from livestock responded dramatically in the first growing season. Vegetation rapidly re-established on eroded streambanks and began the natural process of trapping sediments and narrowing and deepening the stream channel.

Three years into the pilot project on Duck Creek, the rancher, foundation, and Idaho Fish and Game Department cost-shared a pasture subdivision project that will provide increased livestock forage production and complete protection for the riparian area and stream channel.

The key to success was cooperation among fishermen, landowners, and businesses with a stake in restoring and maintaining the overall long-term economic productivity of the area. Fishermen were instrumental in overcoming traditional barriers between fishery and agricultural interests. The key was their willingness to cost-share mutually beneficial solutions instead of simply blaming riparian landowners for the problem. By forming a partnership with the landowner, the foundation avoided spending years and many thousands of dollars proving the obvious. They chose to invest their money and energy in implementing solutions that produced quick results instead of paper.

West Rocky Creek, Texas. West Rocky Creek is located at 1,800 feet elevation in the porous limestone Edwards Plateau in west Texas. Over many decades, heavy overgrazing destroyed native grasses in the area, which were succeeded by dense stands of mesquite and juniper. These deeper-rooted plants used groundwater below the depth grass roots could reach, depleting water that previously had recharged springs and streams. West Rocky Creek became intermittent in 1918 and dried up completely in the 1930s, though it flowed sporadically during periods of above-average rainfall.

In the early 1960s, five ranchers began a range rehabilitation program on their privately owned land with technical assistance and cost-sharing provided by USDA's Great Plains Conservation Program. Extensive, costly brush removal and grass reseeding plus improved grazing strategies were implemented on about half the 74,000-acre watershed. By 1970, springs that had been dry for decades began to flow again on all five ranches. West Rocky Creek began to flow year-round, yielding from 150-4,000 gallons per minute during the severe 1984 drought. Riparian vegetation re-established and streambanks and the stream channel stabilized.

Improving the productivity of the West Rocky Creek watershed produced significant downstream benefits to the city of San Angelo. The quantity and quality of water yielded to water supply reservoirs increased. Reduced sedimentation increased the economic life of reservoirs and decreased water treatment costs.

Continuing good grazing management was a key to the project's success. Some nearby sites received the same brush removal and reseeding treatments, but were improperly grazed. Those sites quickly deteriorated and eventually became reinfested with brush.

Huff Creek, Wyoming Huff Creek is located at 6,600 feet elevation in the mountainous foothills of southwestern Wyoming. It is one of several streams within a 91,000-acre multiple permittee allotment in the Rock Springs District of the Bureau of Land Management.

In the mid-1970s the trout in Huff Creek were identified as a pure strain of Bonneville cutthroat, then under consideration for listing as a threatened species under the Endangered Species Act. To provide emergency protection, in 1976 and 1979 livestock were excluded from stream reaches totaling about one mile in length. Instream structures and rock riprap were installed to elevate the water table, improve trout habitat and reduce streambank erosion.

The area inside the fences responded dramatically. Streambanks healed and the stream channel narrowed and deepened. Within five years the riparian area had roughly doubled in width due to the elevated water table. Vegetation shifted back to grass, and the grass inside the fences stood over two feet high, whereas grass outside the fence was sparse, less than two inches tall, and dominated by sagebrush.

Seeing the demonstrated potential for increasing livestock forage, the livestock association decided to change its grazing strategy for the six-mile-long Huff Creek drainage. A rider was hired to herd stock in the north half of the allotment. Grazing in the Huff Creek valley bottom was delayed until late August through September. The lower half of the valley received light grazing because the herder accelerated the animals' natural drift pattern. Herding and strategically placed salt blocks improved livestock distribution and provided ungrazed forage for stock being trailed to winter pastures.

The number of calves and weight gains improved. In three years, riparian vegetation outside the fence looked the same as vegetation inside the fence. Huff Creek had narrowed by about one third, doubled in depth, and water temperatures had declined. The percentage of eroding streambanks decreased from about 80 percent to about 20 percent, and the number of Bonneville cutthroat increased by over 1,000 percent over 1978 levels.

DOWNSTREAM LINKAGES

One of the most difficult environmental challenges facing the nation concerns the numerous linkages between upstream pollution and downstream impacts. Increasingly, environmental managers are connecting the dots between upstream and downstream and finding creative new ways to work together.

For example, the city of Syracuse, New York, has one of the few unfiltered water supplies in the country and is facing the prospect of investing \$40 to \$50 million in a filtration plant to maintain its water quality. In hopes of avoiding this expense, the city is now prepared to spend \$17 million over 10 years to protect water quality in Skaneatles Lake, the city's source of water.

The Skaneatles Lake Watershed Program helps area farmers install pollution-prevention practices on their farms, promotes land conservation programs on nonfarm areas, and works with other

Photo Credit
S.C. Delaney/EPA

agencies to educate watershed residents about protecting the lake's water quality. The program assigns the highest priority to farms posing the greatest threat to water quality. In the summer of 1996, preparations were underway to implement conservation plans for the seven farms with the most serious conservation needs.

The city of Syracuse will provide up to 100 percent cost-sharing for farmers to install management practices such as intensive rotational management, barnyard water management, and nutrient management. One crop farm that is adopting contour farming is expected to reduce soil erosion by some 322 tons on 240 acres.

The program also is beginning to work with local land trusts to encourage the acquisition of conservation easements, sponsoring seminars and providing technical assistance to nonfarm landowners, and collaborating with the Cornell Cooperative Extension Service to provide education to towns and businesses and to watershed homeowners.

Another important link between upstream practices and downstream effects is the buildup of sediment from upstream sources in downstream harbors. Instead of dredging the harbor, port

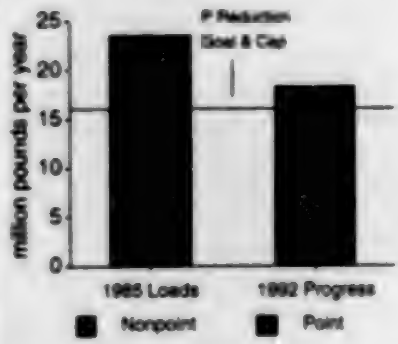
authorities could reduce or avoid such costs by reducing upstream soil erosion.

The Army Corps of Engineers and the Toledo Port Authority are trying the latter approach through a program that helps farmers reduce soil erosion on their land. In an unusual alliance, the Corps of Engineers, USDA's Natural Resources Conservation Service, and the Ohio Environmental Protection Agency are working together to reduce harbor sedimentation by a conservative 15 percent. Part of the funding for the project—$700,000—is coming from the Corps, while NRCS is providing offices, staff, and technical expertise.

NRCS and local conservation districts have set up Sediment Reduction Committees to work with farmers on soil erosion reduction initiatives. By the summer of 1996, a number of projects were underway, including adapting plans for conservation tillage, installing riparian corridors and windbreaks, planting grassy strips in gently sloping waterways, and holding field days to showcase new technologies and tools. In the program's next phase, NRCS will be working one-on-one with farmers to develop resource management plans.

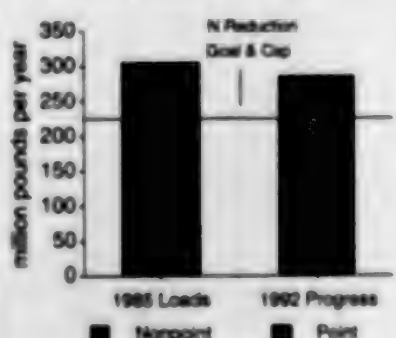
The connection between upstream pollution and downstream effects has also been an important part of the effort to restore the Chesapeake Bay. For example, farming practices along the Susquehanna River in Pennsylvania—miles upstream from the bay—have a profound impact on the health of the bay. The bay states—Pennsylvania, Maryland, and Virginia—have almost 1.5 million acres under nutrient management plans and have cut potential pollutants by 21 percent for phosphorus (Figure 4.21) and 5 percent for nitrogen (Figure 4.22).

Figure 4.21 Phosphorus Loads Delivered to the Chesapeake Bay by Source, 1985 and 1992



Source: U.S. Environmental Protection Agency, Chesapeake Bay Program, Chesapeake Bay Phase II Watershed Model, Annapolis, MD.

Figure 4.22 Nitrogen Loads Delivered to the Chesapeake Bay by Source, 1985 and 1992



Source: U.S. Environmental Protection Agency, Chesapeake Bay Program, Chesapeake Bay Phase II Watershed Model, Annapolis, MD.

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CHAPTER FIVE

The Urban River

For the first settlers along the Atlantic and Gulf coasts, as well as 19th Century pioneers who settled the West, rivers marked the way.

Most early urban settlements were located on or near rivers to be close to water supplies and transportation arteries. Those early patterns of settlement are still evident today. Of the nation's 150 largest cities, 130 are sited along rivers; notable examples include Pittsburgh, Cincinnati, Memphis, St. Louis, Minneapolis, Boise, and Fairbanks. Most of our coastal cities are situated at the mouths of rivers.

For much of the nation's history, urban riverfronts were centers of commerce and industry. In this century, many urban riverfronts gradually declined, as trucks and cars superseded waterborne transportation and many old riverfront industries became obsolete and died. Urban riverfronts often were marred by decaying warehouses and docks or made inaccessible by multilane highways. In some cities, such as Providence, rivers were literally covered over and hidden from view.

Urban areas are a major source of environmental stress on waterways (Box 5.1). Today, thanks in large part to massive investments in pollution control and improvements in river water quality over the past few decades, many urban rivers and harbors are a vital asset in the effort by city officials to bring old downtown areas back to life. For example, Baltimore's Inner Harbor and San Antonio's Riverwalk are two of the nation's recent urban success stories.

In Chattanooga, a five-mile waterfront park has replaced a no-man's land of abandoned factories. The Tennessee Riverwalk will eventually be part of a 75-mile network of city greenways. The $45 million Tennessee Aquarium opened in 1992 and attracted 1.5 million people in its first year. The Chattanooga Audubon Society is now providing access by water taxi to Maclellan Island, a 20-acre downtown nature preserve. The amphibious "Chattanooga Duck" will cruise downtown streets picking up passengers, then roll into the river and travel several hundred yards upstream to the island. Tour guides provide information about the island's history and wildlife, including its great blue heron rookery.

Providence has uncovered its downtown rivers and invested in a river relocation project as part of its urban revitalization effort. Pittsburgh's Station Square, a massive restoration of the city's railroad buildings, is taking advantage of its strategic location along the Monongahela

Box 5.1
The Environmental Impact of Urbanization

Urbanization has a variety of impacts on rivers. As small towns grow into cities, trees that once intercepted rainfall are felled, natural dips or depressions that once held rainwater are lost through grading and filling for development, wetlands are destroyed, and layers of natural vegetation are replaced by impervious paved surfaces such as roads and roofs. As these changes occur, runoff increases and reaches water bodies faster and with greater force. The land loses its capacity to absorb and store rainwater, the groundwater table drops and stream flows decrease during dry weather.

Increases in paved surfaces can be directly linked to the accelerated loss of aquatic habitat. Urban runoff passes over and is warmed by paved surfaces and structures, eventually raising stream water temperatures. Even a slight increase in stream temperature can adversely affect some aquatic life and the insects in and around a watershed.

Heavier sediment loads clog streambeds with sand and silt, destroying habitat. Development which inevitably requires that roads and pipelines cross streams, rivers, and wetlands, can upset ecosystems and block the movement of fish. Wildlife habitat also is affected by the replacement of vegetation by roads and structures.

Urban runoff carries pollutants from many sources and activities—automobiles, oil and salt on roads, atmospheric deposition, processing and salvage facilities, chemical spills, pet wastes, industrial plants, construction site erosion, and the disposal of chemicals used in homes and offices. In many of the nation's older cities, combined sewer overflows are used to handle stormwater runoff. During some storms, stormwater mixes with raw sewage and is discharged.

Urban rivers inherit some problems from upstream, notably sediment, nutrients, and pesticides from non-point sources. But cities add a panoply of new pollutants into the river, including:

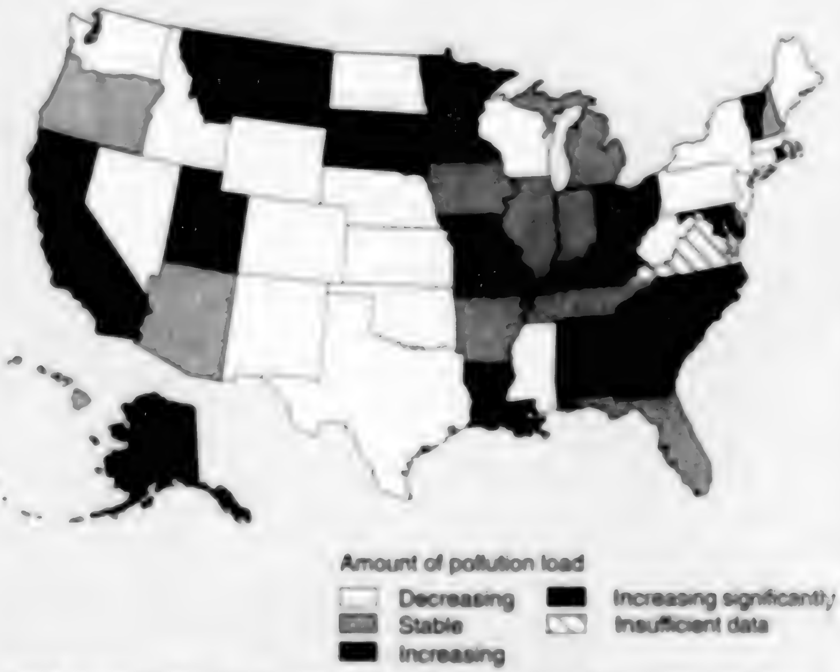
- *Bacteria.* Urban runoff often contains high levels of harmful bacteria and viral strains, including fecal streptococcus and fecal coliform from human and animal wastes. When these levels exceed public health standards, drinking water may be unsafe, beaches may be closed, and harvesting shellfish beds may be restricted.
- *Oil and grease.* Oil, grease, and other petroleum-based substances contain hydrocarbons, some of which are harmful to sensitive animal species and aquatic life. Hydrocarbons degrade fisheries habitats and lower dissolved oxygen by limiting the interaction of water and air.
- *Heavy metals.* Heavy metals—including lead, copper, cadmium, zinc, mercury, and chromium—can be toxic to aquatic life and contaminate drinking water supplies. Most metals found in urban runoff come from corroding, decaying surfaces, including roofing materials, downspouts, galvanized pipes, metal plating, paint, catalytic converters, brake linings, and bridges and other structures.
- *Toxic substances and chlorides.* Toxic substances, which are found in household substances such as paint and cleaning materials, can seriously impair water quality. Chlorides or salts—used to remove ice and snow from roads and sidewalks—are toxic to many aquatic organisms and can have a major impact on groundwater.
- *Trash and debris.* Trash and debris from street litter and careless disposal washes into water bodies both over land and through the storm drain system, collecting at impasses in streams and lakes and disturbing water flow.

River. Both of these efforts, which are described in more detail later in this chapter, are generating substantial private investment: Station Square has already attracted $87 million in private investment and expects to raise an additional $150 million in private funds.

River restoration projects are an important way to restore and celebrate the unique cultural characteristics of urban neighborhoods and bring needed green space to developed downtown areas. Most such projects attract strong community support. Community groups, in turn, can be valuable sources of volunteer labor to help clean up old urban waterfronts and push for improved riverfront access and amenities. Friends of the Chicago River, for example, has done everything from river cleanup projects to literally redesigning riverfront architecture.

The federal government, through traditional environmental protection, urban restoration programs, and new efforts such as Empowerment Zones and the redevelopment of urban brownfields, is providing strong incentives for the restoration of urban areas.

Figure 5.1 Point Source Loading Trends for BOD by State, 1990-1995



Source: U.S. Environmental Protection Agency, Office of Water, *Environmental Indicators of Water Quality in the United States: Fact Sheets*, EPA 841-F-96-001 (EPA, OW: Washington, DC, 1996).

Note: BOD = Biochemical Oxygen Demand. Data compare total state discharges between the years 1990 and 1995.

URBAN WATER QUALITY

The challenge of managing urban water quality falls into two distinct parts. First, there is the traditional issue of managing point source discharges. Boston Harbor, an example of the point-source challenges facing older cities, is discussed in the next chapter. Second, there is the issue of nonpoint pollution.

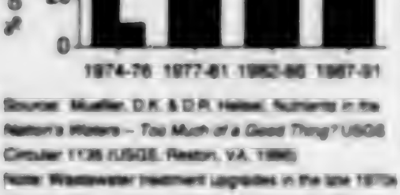
Since passage of the Clean Water Act in 1972, most of the conspicuous point source water pollution of the late 1960s and 1970s has been eliminated. During the 1972-92 period, the U.S. population and the amount of sewage treated at wastewater treatment plants each rose about 30 percent, yet biochemical oxygen demand (BOD) – an indication of organic pollutant loading – from treatment plants declined by 36 percent. National Pollution Discharge Elimination System (NPDES) permits, which limit the amount of pollution that can be discharged from industries and sewage treatment plants, have been issued for about 48,000 industrial facilities and about 15,000 municipal facilities nationwide. All told, EPA's NPDES permit, pretreatment, and biosolids programs now regulate over 500,000 sources.

In 1995, 66 percent of states reported BOD as either decreasing or stable (Figure 5.1). Recent improvements in wastewater treatment have also decreased ammonia concentrations downstream from some urban areas, but the result has been an increase in nitrate concentrations (Figure 5.2). This condition limits the direct threat of toxicity to fish and other aquatic life but does not change the potential for eutrophication downstream.

Another significant trend identified in urban rivers and streams has been the sustained decrease in phosphorus caused by limits on phosphorus content in detergent and by additional treatment used in some plants to remove phosphorus. The Potomac, Chattahoochee, Connecticut, and several other urban rivers have all shown decreases in phosphorus concentrations as a result of decreased phosphorus in wastewater effluent (Figures 5.3 and 5.4). Direct discharges of toxic pollutants are also down dramatically since 1988 (Figure 5.5). (For more on the federal framework for point source pollution control, see Box 5.2.)

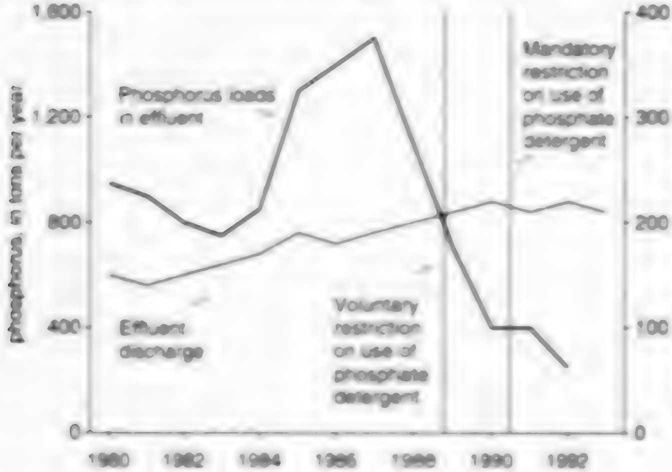
A major urban challenge is to reduce nonpoint pollution. Urban managers have two broad methods to reduce non-

Figure 5.2 Results of Sewage Treatment Plant Improvements, Dallas, Texas, 1974-1991



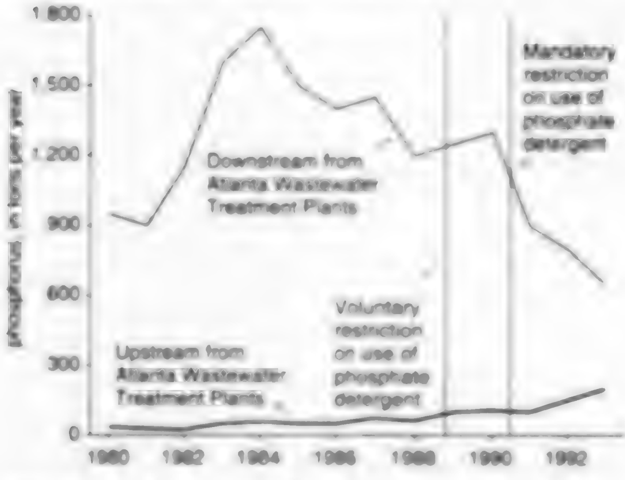
Source: Mueller, D.K. & D.R. Helsel, *Nutrients in the Nation's Waters – Too Much of a Good Thing?* USGS Circular 1136 (USGS, Reston, VA, 1996).
Note: Wastewater treatment upgrades in the late 1970s changed the predominant form of nitrogen in effluent from ammonia to nitrate. This reduced the potential for fish kills but not for eutrophication because the total amount of nitrogen in effluent is not necessarily reduced.

Figure 5.3 Phosphorus Loads in Wastewater Treatment Plant Effluent in the Chattahoochee River, 1980-1993



Source: Wangsness, D.J. et al., USGS Open-File Report 94-99 (USGS, Reston, VA, 1994)

Figure 5.4 Phosphorus Concentrations in the Chattahoochee River Near Atlanta, Georgia, 1980-1993



Source: Wangsness, D.J. et al., USGS Open-File Report 94-99 (USGS, Reston, VA, 1994)

Educational programs are an important part of the Anacostia River restoration effort.

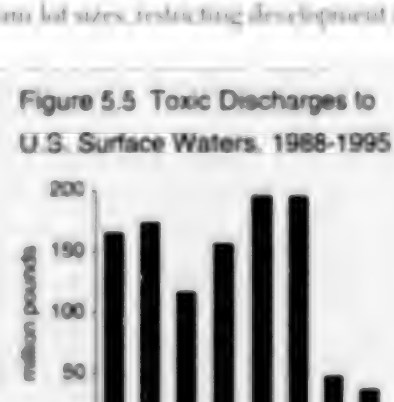
Photo Credit:
E.C. Delaney/EPA

point-source urban pollution – the installation of "best management practices" (BMPs) that can control or reduce pollution, and ongoing pollution prevention programs that can reduce the amount of pollution generated. In most cases, pollution prevention is more cost-effective than structural measures. Both strategies are generally necessary to fully control the effects of urbanization.

Among the options for pollution prevention, local governments can consider collecting and recycling crankcase oil, beginning leaf and other yard waste collection, establishing catch basin drainage programs, redesigning road salting techniques, starting remedial erosion control, removing illegal and improper industrial and commercial connections to storm drains, and plugging or sealing abandoned wells and cisterns.

Best management practices for a development site include using downzoning to restrain development, specifying minimum lot sizes, restricting development in

Figure 5.5 Toxic Discharges to U.S. Surface Waters, 1988-1995



Source: See Part II, Table 6.6

Box 5.2
Point Source Pollution Control: The Federal Framework

Under the Clean Water Act, industrial facilities are required to comply with technology-based effluent limitations. These technology-based controls, defined as effluent limitation guidelines, have been specified for over 50 kinds of industries. Similarly, municipal sewage treatment plants are required in most areas to provide at least secondary treatment to assure that 85 percent of conventional pollutants, such as organic waste and sediment, are removed.

Today, most facilities are in compliance with their permit conditions (Box Figure 5.1). Of the 3,731 major municipal facilities, all but 423 achieved compliance with the Clean Water Act by July 1, 1988. Since that time, 188 more facilities have come into compliance and, of the remaining 235 facilities, all but 50 have been placed on enforceable compliance schedules.

Pretreatment is another important focus of the nation's point source control program. Across the nation, there are some 270,000 industrial users discharging their waste to publicly owned treatment works (POTWs). For these industrial users, EPA has developed "pretreatment" regulations for pollutants that a) interfere with the operation of a POTW, including interference with its use or disposal of municipal sludge, or b) pass through the POTW and contaminate receiving streams or are otherwise incompatible with the operation of the treatment works.

Currently, 31 of 43 NPDES-authorized states have approved pretreatment programs. In addition, 1,576 POTWs have been required to develop pretreatment programs, of which 1,535 (97 percent) are approved. Pretreatment POTWs receive about 80 percent of national wastewater flows—about 30 billion gallons per day.

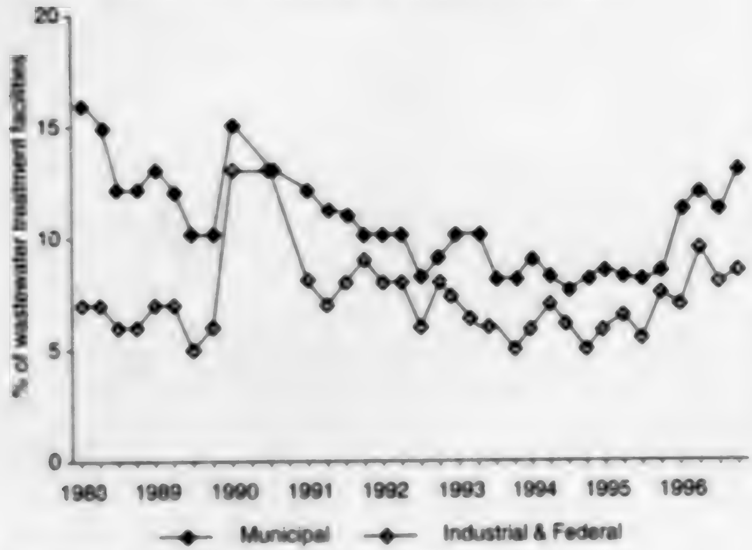
Implementation of secondary and advanced treatment at wastewater treatment plants has increased the amount of biosolids generated by these plants. Municipalities currently generate about 7 million dry metric tons of biosolids per year. Several management options exist. Since biosolids contain nutrients and have physical properties that make them useful as a fertilizer and soil conditioner, one attractive option is to use biosolids on agricultural lands, in forests, for landscaping projects, and to reclaim strip-mined land. Regulation of biosolids is important, however, because improper disposal can harm surface water, groundwater, wetlands, and public health. In February 1993, EPA published standards for the use or disposal of biosolids.

EPA has outlined the requirements for states to seek EPA approval to operate state biosolids management programs. Two state programs, Utah and Oklahoma, were approved by the end of 1996. In February 1997, EPA proposed streamlining changes to the permitting regulations to make it easier for states to become authorized.

About 1,000 communities, mainly in the older cities of the Northeast and Midwest, use combined sewer overflows (CSOs), which are designed to carry sanitary and industrial wastewater combined with stormwater. In major storms, the capacity of these systems is exceeded and part of the combined flow is discharged untreated into rivers, lakes, and estuaries. Under the Clean Water Act State Revolving Fund Program (SRF), states have the flexibility to address high-priority concerns such as CSO controls. To date, loans totaling more than $17 billion have been made to fund more than 5,500 clean water projects in all eligible categories.

In many of the nation's older cities, the physical infrastructure to manage and treat point source discharges is outdated and subject to numerous breakdowns. In its 1996 national survey of municipal wastewater treatment needs, EPA found a total of $128 billion in documented and modeled needs—including $44.7 billion in modeled needs for combined sewer overflows— that are eligible for SRF funding.

Box Figure 5.1 Facilities in Significant Noncompliance with NPDES Permit Requirements by Quarter, 1988-1996



Source: U.S. Environmental Protection Agency, 1997

sensitive areas, increasing development density through cluster development that preserves green space, allowing no modification of the natural floodplain, prohibiting development in nontidal wetlands, retaining trees, reserving some open space, revegetating immediately after construction, providing for stormwater collection or treatment, and maintaining infiltration capacity by using natural drainage conditions where possible.

Vegetation controls can be valuable in controlling urban nonpoint pollution. For example, landscaping can route stormwater runoff through green areas and away from erosion-prone steep slopes and other areas. Grassed swales—depressions, or gullies, which transport runoff—are often used in residential developments and on highway medians as an alternative to curb and gutter drainage systems. Swales can control peak discharges by reducing runoff velocity and allowing some runoff to infiltrate the soil. But their effectiveness varies from site to site, and they require continual maintenance.

The Clean Water Act's State Revolving Fund (SRF) has the potential to become a major source of funding for nonpoint source, wetlands, and estuary projects. Eligible projects, which must be in a state's Nonpoint Source Management Plan, include those that reduce runoff from agricultural lands or urban areas, protect or improve wetlands, improve stream banks and shoreline, and many others. So far, 17 states have provided over $650 million for approximately 900 nonpoint source projects. In addi-

tion, $5 million has gone towards estuary projects. EPA is working with the states to increase the use of the SRF for projects other than traditional wastewater treatment activities.

GETTING PEOPLE INVOLVED

Citizens groups are a valuable weapon in the fight against urban pollution and the restoration of urban rivers.

As part of a total water quality monitoring program and assisted by qualified specialists, citizen groups can collect valuable information on stream water quality. They can monitor and identify problems, collect surface water samples, and measure turbidity. Citizen monitoring is also a valuable tool to build grassroots interest in water quality issues. Citizens groups can play an important role in building public support for urban pollution control programs.

Two cases—the Anacostia River in Washington, D.C., and the Chicago River in Chicago, Illinois—are characteristic examples.

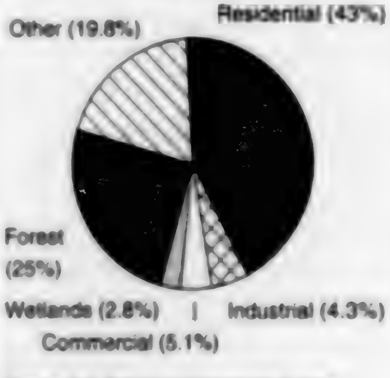
The Anacostia River

The headwaters of the Anacostia—in Prince Georges and Montgomery counties in Maryland—are in rural or suburban areas with relatively low population densities but rapidly increasing development and population growth. The tidal portion of the river flows through a densely populated urban area lying mostly in the District of Columbia. The lower Anacostia flows through some of the poorest neighborhoods in the District of Columbia, which are mostly African American. It is among the most polluted river sections in the nation, and fish contamination is a critical issue because fish from the river are regularly eaten by neighborhood residents.

Typical of a watershed with agricultural, suburban, and urban land uses (Figure 5.6), the Anacostia has been subjected to nonpoint source pollution and stream degradation. Nearly 60 percent of streams in the Maryland portion of the watershed lack a riparian buffer that is at least 100 meters on each side (Figure 5.7). As a result, sediments, nutrients, toxic compounds, and water with elevated temperature flows into the river.

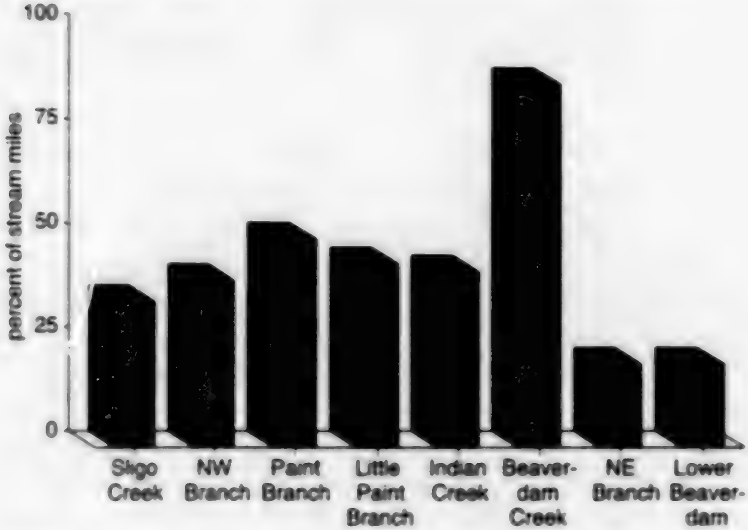
Urbanization has profoundly altered the flow, shape, water quality, and ecology of the Anacostia's streams, leaving many with only a fraction of their original biological diversity. Populations of fish and other aquatic organisms are

Figure 5.6 Land Use/Land Cover in the Anacostia Watershed, 1990



Source: U.S. Environmental Protection Agency, Anacostia Watershed (an Internet-accessible report), 1997.

Figure 5.7 Riparian Forest Buffer in the Anacostia Watershed by Tributary, 1990



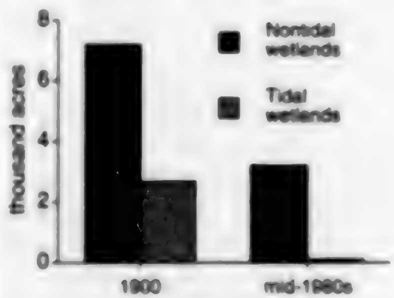
Source: U.S. Environmental Protection Agency, *Anacostia Watershed* (an Internet accessible report), 1997

greatly reduced from historic levels and are generally sparse. Fish have been contaminated with PCBs and chlordane, and there is a fish-consumption advisory for bottom-feeding fish for all D.C. waters.

More than 98 percent of tidal wetlands along the river were lost to filling/dredging operations and seawall construction, and nearly 75 percent of the Anacostia watershed's freshwater wetlands have been destroyed by agriculture and urbanization. Today, it is estimated that there are fewer than 100 acres of emergent tidal wetlands left (Figure 5.8).

A recent report by the Metropolitan Washington Council of Governments evaluated the amount of pollution received annually by the Anacostia and its tributaries from nonpoint sources, point sources, and combined sewer overflows, with primary attention to nitrogen, phosphorus, 5-day bio chemical oxygen demand, lead, zinc, and total suspended

Figure 5.8 Wetlands in the Anacostia Watershed, 1900 and mid-1980s



Source: U.S. Environmental Protection Agency, *Anacostia Watershed* (an Internet accessible report), 1997

Debris along the Anacostia River

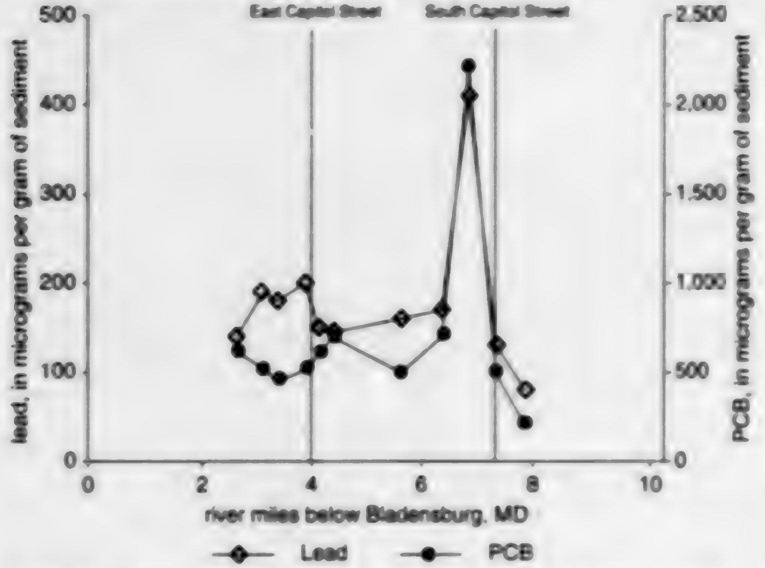
Photo Credit
S.C. Delaney/EPA

solids. Findings show that nonpoint sources comprise 75 to 90 percent of the total annual loads, while point loadings from the 30 permitted municipal and industrial facilities in the watershed account for only one percent or less. Combined sewer overflows typically contribute five to 25 percent of the total annual pollutant loads to the river, except for lead, where combined sewer overflows contribute about 85 percent of the annual load. Although erosion control has been required for new development for 15 years, much of the Anacostia basin was developed prior to these regulations.

Severe sedimentation and high bacteria levels are common throughout the basin. Many sediments contain hydrocarbons, heavy metals, and other toxic compounds (Figure 5.9), and nutrients. Pollutant levels are three to 20 times higher during storms. Dissolved oxygen levels seasonally fall below water quality standards in the tidal area and frequently fall below the standards in the upper reaches. Debris from upstream also is a serious problem.

The Anacostia River Watershed Restoration Initiative. The Anacostia River Watershed Restoration Initiative was conceived by representatives of state and local jurisdictional areas over a period of several years. An important partner in the effort has been the Metropolitan Washington Council of Governments, a regional organization that includes repre-

Figure 5.9 Contaminated Sediment Concentrations in the Tidal Anacostia River, 1992



Source: U.S. Environmental Protection Agency, *Anacostia Watershed* (an Internet accessible report), 1997

sentatives from the District of Columbia and major counties and cities in suburban Maryland and northern Virginia.

In 1979, the Council's Water Resources Planning Board identified the Anacostia as a priority watershed that was critical in the effort to restore the Potomac River basin. In 1984, jurisdictions in the watershed signed the Anacostia River Watershed Agreement, targeting two major pollutants—raw sewage from combined sewer overflows in the District of Columbia and sediment runoff and erosion from Maryland.

In 1987, a new restoration agreement was signed that set goals for restoring the river. The agreement spurred creation of the Anacostia Watershed Restoration Committee, with six members from the District of Columbia, the state of Maryland, and Prince Georges and Montgomery counties in Maryland plus the Metropolitan Council of Governments as the lead agency. The Interstate Commission on the Potomac River Basin was asked to coordinate public education programs, and in 1991 the Army Corps of Engineers was invited to join the committee to represent federal agencies.

In 1991 and 1992, the committee devised a set of six goals and strategies to help restore the river by the turn of the century. Some of the progress towards achieving the goals is shown in Figure 5.10.

- *Goal 1.* Dramatically reduce pollutant loads in the tidal estuary. *Strategy:* Sharply reduce the number of sewage overflow events and stormwater pollutant loadings. Prevent increased stormwater loadings from new development. Remove trash and floatable debris trapped in the estuary and prevent future trash accumulation.

- *Goal 2.* Restore and protect the ecological integrity of degraded urban Anacostia streams to enhance aquatic diversity and encourage a quality urban fishery. *Strategy:* Apply stream restoration techniques to improve habitat and require strict land-use controls and stormwater and sediment practices at new development sites.

- *Goal 3.* Restore the spawning range of anadromous fish to historical limits. *Strategy:* Remove key barriers to expand the available spawning range for anadromous fish. Improve the quality of the watershed's spawning habitat.

- *Goal 4.* Increase the natural filtering capacity of the watershed by sharply increasing the acreage and quality of tidal and nontidal wetlands. *Strategy:* Accept no further net loss of wetlands in the watershed. Restore the ecological function of existing degraded wetland areas. Create several hundred acres of new wetlands.

- *Goal 5.* Expand forest cover throughout the watershed and create a contiguous corridor of forests along the margins of its streams and rivers. *Strategy:* Reduce the loss of forest cover from new development through local implementation of Maryland's 1991 Forest Conservation Act. Reforest suitable sites throughout the basin. Reforest 10 linear riparian miles by 1994, with the ultimate goal of an unbroken forest corridor from the tidal river to the uppermost headwater streams.

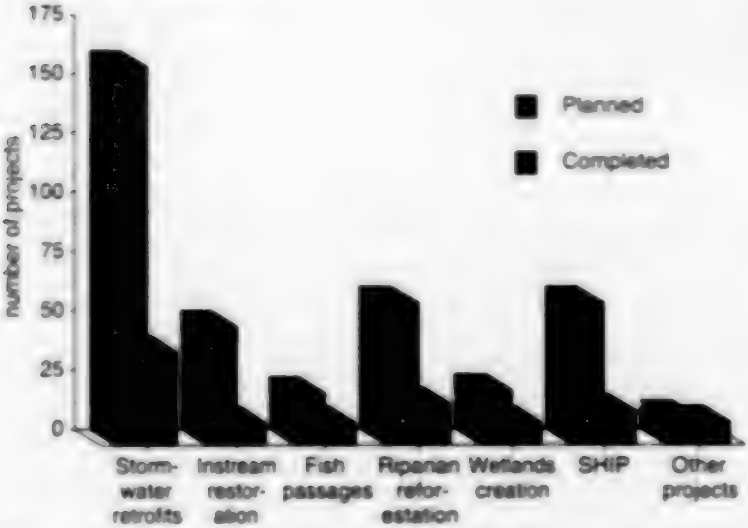
- *Goal 6.* Make the public aware of its role in the Anacostia River cleanup and increase public participation in restoration activities. *Strategy:* Raise public awareness of the river's problems and the restoration effort. Encourage a grassroots network of citizens to participate in a variety of ways.

A case study prepared by the Interagency Ecosystem Management Task Force noted that the Six-Point Action Plan provided a good initial framework for action, but was not comprehensive enough in terms of planning, coordinating, monitoring, and evaluating to provide a vision for restoring the watershed.

Cooperative projects in the Washington area present a difficult challenge of coordinating a wide variety of federal, state, and private interests. Particularly challenging is finding representation for the federal government, when so many federal agencies may have an interest in such projects. Although federal programs and activities were praised for supporting and facilitating basin restoration, the authors of the case study heard repeated criticism that federal restoration initiatives were not well-coordinated.

There also appeared to be a tension between, on the one hand, the desire and need for coordinated federal participation

Figure 5.10 Status of Restoration Projects in the Anacostia Watershed as of 1994



Source: U.S. Environmental Protection Agency, Anacostia Watershed (an Internet accessible report), 1997.
Note: SHIP = Small Habitat Improvement Program

and funding, and, on the other hand, a fear that federal involvement could overwhelm or derail local efforts.

The difficulties in forging effective public participation were evident in May 1994, when the Anacostia Watershed Restoration Committee published a four-point outreach plan calling for increased elected official participation, increased opportunities for citizen participation, increased public awareness of the restoration effort, and a formal mechanism for providing greater citizen input into the restoration committee's activities.

The authors of the case study found that some participants felt there were insufficient efforts to involve the watershed's low-income communities in the restoration effort. Residents of these communities also faced pressing problems of homelessness, unemployment, and crime that tended to compete with environmental issues for the attention of community members.

Nevertheless, there have been a number of successes in both the educational and public participation aspects of the project. In 1991, for example, the Chesapeake Bay Foundation began an environmental education program on the tidal Anacostia and the Chesapeake Bay that reaches several thousand District of Columbia students each year. Montgomery County has developed a program for training teachers and helping them incorporate Anacostia restoration issues into the school system's curricula. In the District of Columbia, the Kramer Middle

School for Environmental Studies is forming its curriculum around environmental themes. Students at Kramer will study the Anacostia and its relationship to the Potomac River and the Chesapeake Bay.

In July 1994, under the aegis of the Chesapeake Bay Program, federal agencies signed an agreement on ecosystem management in the Chesapeake Bay, including an agreement on a federal workplan to clean up the Anacostia in cooperation with the Anacostia Watershed Restoration Committee.

Three months later, EPA Region III announced its Anacostia Ecosystem Initiative, which focuses on watershed restoration, multi-media risk reduction, environmental justice, and public education and involvement. As part of the initiative, EPA hired a community liaison staffer who maintains regular contact with citizens, community leaders, and interest groups on both the day-to-day and long-term aspects of the restoration effort. In May 1996, the relationship between EPA and local groups was formalized in a memorandum of understanding between EPA and the Anacostia Watershed Restoration Committee.

Several initiatives have stemmed directly from the 1994 agreement with federal agencies. In March 1996, a Special Tributary Strategy for Federal Lands in the District of Columbia was signed by 18 federal officials. This voluntary agreement calls for improved control of stormwater runoff on all federal lands in the District of Columbia and supplements the District's strategy to meet the 40 percent nutrient reduction goal of the Chesapeake Bay Program. In November 1996, a draft Biennial Federal Workplan for the Anacostia River Watershed was introduced by the Chesapeake Bay Program and the Baltimore District of the U.S. Army Corps of Engineers in cooperation with the Anacostia Watershed Restoration Committee. The workplan translates the committee's six-point action plan into specific actions to be undertaken by federal agencies and facilities that impact water quality in the Anacostia and its watershed. In October 1996, supported by grants from the Chesapeake Bay Program, the District of Columbia completed a regional action plan for toxics that defines a series of steps to minimize toxic loading into the Anacostia.

Since the start of the Anacostia Ecosystem Initiative in 1994, EPA Region III has channeled more than $1 million to projects designed to generate community involvement and awareness, including fish advisory signs along the river, educational canoe trips for school children, science fairs and festivals, comparative risk studies on overall health risk, and environmental justice projects. Another $2.5 million has been used for general environmental protection work in the District of Columbia and Maryland. Since 1996, the Corps of Engineers has spent about $6 million on restoration projects and $2 million on planning and engineering studies. (Figure 5.10)

The Chicago River

The Chicago River travels through the heart of downtown Chicago, through natural, suburban, and industrial areas, and

Friends of the Chicago River volunteers and Youth Corps members work to restore Prairie Wolf Slough

Photo Credit:
Friends of the Chicago River

ultimately discharges into the Des Plaines and Illinois rivers in the farmland of central Illinois.

For most of its recent history, the river has been at the mercy of urban development. At the turn of the century, the river's flow was reversed to minimize pollution to Lake Michigan, the source of Chicago's water. The city's 19th Century sewer system was designed to handle both sewage from plumbing and runoff from streets. Through the 1970s, the system overloaded almost 100 times per year, causing raw sewage intended for treatment facilities to flow directly into the Chicago River.

Along the river's South Branch, from Harrison Street to Ashland Avenue, are wide expanses of industrial land, much of it owned by railroads, utilities, and investors. The North Branch south of the North Shore Channel flows through areas of heavy industry, including foundries, breweries and warehouses, as well as parks and residential neighborhoods. The downtown portion of the river includes major commercial and residential projects, along with several riverside parks and plazas.

In the 1960s and 1970s, millions of dollars were invested to clean up pollution from industrial sources and treatment plants, yet the sewage overflow problem continued to plague the river. The sewage had reduced the river's clarity to no more than a foot or two in spots, and the lack of oxygen was killing fish and other wildlife. In the summer of

1975, the Metropolitan Sanitary District (MSD) removed more than two tons of dead carp, alewives, and goldfish from a mile-long stretch of the North Shore Channel in Evanston.

To solve the sewage overflow problem, the Sanitary District designed the Tunnel and Reservoir Plan, otherwise known as TARP or the Deep Tunnel. The project consisted of 125 miles of tunnels 15 to 30 feet wide and some 150 to 300 feet beneath the ground. The system was designed to catch almost all of the overflow from the 3,000 miles of existing sewers and send it to treatment plants.

TARP succeeded in greatly reducing the incidence of sewage overflows into the river. As a result of improving water quality and other factors, land uses along the river began to change. Recreational use of the river increased, and wildlife began to return to the river corridor. By the late 1970s, the river held great promise for redevelopment, yet something was missing. Writing in *Chicago* magazine in 1979, Robert Cassidy said:

"The main reason why so little has been done is that the river has no advocate. The parks have Friends of the Parks. Lincoln Park Zoo has Friends of the Zoo. The river, alas, is friendless. Worse still, the many federal, state, and local agencies (27 at last count) that deal with river-related problems are often at odds over trivial matters.... The first step, then, is to get everyone who has a stake in the river's future to participate in a Friends of the River advocacy group."

Friends of the Chicago River. Thus was born Friends of the Chicago River, which has grown to over 1,000 members and has been remarkably successful as a guardian of the Chicago River and its waterways.

Established in 1979, Friends of the Chicago River has organized grassroots support for cleanups and formed partnerships with business, government, and community groups to restore the river system.

Among its grassroots events, Friends sponsors the Great Chicago River Rescue Day. In June 1996, about 500 volunteers picked up about 10 tons of trash from 19 sites along the Chicago River and waterways. In a single 200-yard stretch of the river, volunteers picked up food wrappers, hardened sacks of cement, three syringes, lampshades, baby bottles, broken glass, rusted soda cans, shoes, a fuel tank, radiator grill, tire, car bumper, safe, toy, stuffed leopard, and a set of bed springs embedded in the river so long that a tree was growing out of it.

The effort seems to help discourage using the river as a trash can. During the 1996 cleanup, volunteers noticed that areas cleaned up in 1995 had remained fairly clean. The volunteers also helped restore river banks by planting native grasses and flowers and removing non-native plants.

Friends has gone substantially beyond river cleanup. For example, working with the Chicago Department of Planning, Friends helped develop an environmentally friendly set of urban design guidelines for the downtown corridor that was approved by the Chicago Plan Commission in 1990 and is used by the City of Chicago to review proposals for development on the waterway. The guidelines'

main objectives are to establish a riverside walkway through the downtown river corridor, create green space, and transform the downtown river reaches into a high-profile tourist attraction and recreational amenity. The guidelines are specific:

- The river elevation of any riverside building should be treated architecturally as one of the principal facades. Every effort must be made to take advantage of river views, from the standpoint both of someone looking out of the project from within and looking at it from a distance.

- To accommodate riverside walkways, buildings throughout the river corridor must be set back from the river edge a minimum of 15 feet at dock level and an additional 15 feet at street level and above for a total setback of 30 feet. The optimal setback is 50 feet.

- To provide a livelier view for passersby, the use of reflective glass at dock or street level should be avoided.

- Where the river has not been "hardened" with bulkheads or seawalls, the natural river edge should be preserved. Trash and debris should be removed. Vegetation may be pruned to improve views of the water. Steep riverbanks may be recontoured to provide a gentler slope.

- When existing bulkheads must be rebuilt or replaced or new bulkheads installed, edge treatments that would give the riverbank a more natural appearance should be employed. Derelict bulkheads should be removed. If a hard edge is necessary, concrete or masonry steps that would permit access by small craft should be provided. Both new and existing bulkheads should be clad in attractive materials.

Friends is also active in both education and training programs.

- In 1996 and 1997, the Chicago River Schools Network, which gives schools access to in-school slide shows, river-related art projects, water-quality monitoring, wetlands planting, and other field activities, included 50 local high schools, elementary schools, colleges, and universities.

- Urban Canoe Adventures (U-CAN) is a program to recruit urban young people to be trained as canoe guides. Each trainee learns paddling skills and river history and is matched with a mentor recruited from an environmental field. Partners in the program include public schools, forest preserve districts, and the Chicago Academy of Sciences. Funding has been provided by the North American Fund for Environmental Cooperation, the National Fish and Wildlife Foundation, and other sources.

Working with the National Park Service's Rivers, Trails, and Conservation Assistance Program and several other federal agencies, Friends has for several years been actively engaged in creating demonstration projects to restore the river along its entire 156-mile length. Two such demonstration projects—Prairie Wolf Slough and Gompers Park—involve wetlands restoration.

In southeastern Lake County some 30 miles from Chicago, the North Branch of the Chicago River is a modest 15-foot waterway flowing through an orphaned farm field in a suburban area immediately adjacent to a retail shopping mall. The site is owned by the Lake County Forest Preserve District.

The Prairie Wolf Slough demonstration project is designed to restore 42 acres of former wetlands, prairie, and savanna. Friends is an active partner in this collaborative project, which has attracted enthusiastic local support plus funding from state and federal agencies, including the Fish and Wildlife Service.

The project's first priority is to restore the wetlands' hydrology, clear away non-native vegetation, and plant wetlands, prairie, and savanna vegetation. Led by staff from Friends and local agencies, such as the Lake County Forest Preserve District, volunteers planted 51,000 wetlands plants in 1996. The initial plantings have fared well and are the basis for an ever increasing diversity of plant life.

One of the questions the project is trying to answer is the relationship between different plant communities and groundwater levels. The DePaul University Environmental Sciences Department is managing a long-term groundwater monitoring study at the project site. The water wells they have installed will be measured periodically to study groundwater flow and provide estimates of the new plants' drinking habits. The monitoring should provide information on the fluctuating water needs of plant communities to determine optimal planting times and the best seed mixes for wetlands.

The project also includes new environmental education projects for nearby schools, including construction of a loop trail with interpretive signage and a connecting trail between the wetlands, a high school, and a local park district property.

Working together, the Chicago Park District and Friends have spearheaded a project to restore 1½ acres of wetlands at Gompers Park along Foster Avenue in the heart of the city. The site was selected from 12 potential areas within the city because it had strong community support and because local schools wanted to use it for ecology education. The Chicago Park District, which manages the project's restoration component, felt that it would be an excellent model for restoring other urban parks.

Projects such as Gompers Park can also play a valuable role in bringing people together.

"The great thing about these projects is that they can create social links between people that never would have formed otherwise. And it allows the community to contribute to the environment along the river," according to Geri Weinstein of the Park District.

Friends receives funding from grants, foundations, membership fees, and individual donations. The Gompers Park Wetlands project received $50,000 from the Urban Resources Partnership (URP), which finances natural improvement projects in the Chicago area. The Prairie Wolf Slough project received $78,000 from URP and additional funding from EPA's Region 5 office and the Lake

County Stormwater Management Commission.

WATERSHEDS AND COMMUNITY WATER SUPPLIES

Americans have come to expect that reservoirs and aquifers would provide plentiful supplies of water in most regions, and that chlorination and filtration would remove most waterborne diseases and surface-water pollutants. But residential development and other factors are putting drinking water at risk. For the nation as a whole, EPA has estimated the capital cost of treating, storing and delivering safe drinking water at $138.4 billion over the next 20 years.

A frequently overlooked but promising approach to maintaining safe drinking water supplies is to invest in watershed protection. Many of these initiatives are described in a recent report by the Trust for Public Land, entitled *Protecting the Source: Land Conservation and the Future of America's Drinking Water Supply*.

For example, the state of New Jersey's new master plan for statewide water management abandoned plans for increasing capacity and instead emphasizes water resource protection, water management, and water conservation. Threatened with development in a forest that is the watershed for some 2 million people, New Jersey used state money plus other sources to buy about 17,500 acres for $55 million, leaving the developer with 2,200 acres of the least sensitive land for development. The primary watershed was protected and the two states gained badly needed parkland.

Similarly, voters in California recently approved statewide funding land acquisitions for watershed protection. Residents of Spokane, Washington, are paying $15 a year to fund watershed acquisitions, while Providence, Rhode Island, is considering a tax on water usage for this purpose.

The town of Gunnison, Colorado recently spent over $500,000 to buy the 400-acre Van Tuyl Ranch, which sits directly atop the town's aquifer. City officials concluded that development would curtail groundwater recharge and increase pollution, which could threaten the town's drinking water. Preserving the ranch as a hay-growing facility will protect the town's water supply as well as preserve open space.

The federal government increasingly supports these kinds of approaches. The 1996 amendments to the Safe Drinking Water Act, which authorized a Drinking Water State Revolving Fund at up to $1 billion per year, provides that, at the state's discretion, up to 10 percent of the state's capitalization grant money may be used to provide loans to public water systems to acquire land or conservation easements from a willing seller or grantor to protect the source water and to ensure compliance with national drinking water regulations. The amendments require states to assess the susceptibility to contamination of public water supplies and provide the results of these assessments to the public. The law also provides a source of federal funds for the assessments.

Under the Clean Water Act's nonpoint source grant program, the Environmental Protection Agency in 1995 approved a $250,000 grant to the city of Waynesville, North Carolina, which the city intends to use to protect one of two acquisition priorities in its watershed.

Without watershed protection, cities may be required by EPA to build costly filtration plants. Portland, Maine, which relies on nearby Lake Sebago for its drinking water, is on the cusp of this dilemma. Six towns border the lake, and there are some 2,700 residences within 200 feet of the shoreline.

To ensure safe water quality, the Portland Water District has purchased roughly 98 percent of the land—about 1,500 acres—in a 2-mile shoreline zone that includes the district's two intakes. Within this zone, swimming and all other body-contact activities are prohibited. To manage possible giardia contamination, the district also constructed an ozonation facility. Many other regulatory mechanisms—affecting zoning, minimum lot sizes, plumbing codes, and septic systems—have been instituted to protect the lake's water quality. All of these measures have combined to ensure high levels of water quality and enable the district to avoid construction of a filtration plant, which would cost $25 million to build and $750,000 per year to operate.

The Chattahoochee River, which supplies the Atlanta region's water, is stressed by intense development and growth. Efforts are underway to augment the Chattahoochee National Recreation Area and negotiate conservation easements with developers. In one recent case, the builder of a 600-home subdivision near Lake Lanier agreed to protect a 200-foot buffer between the development and the river.

Altogether, some 140 cities have sufficiently clean water that EPA does not require filtration plants. However, many of these cities do not control their watershed and are faced with the possibility of development-related pollutants in the future.

San Antonio. The Edwards Aquifer is the sole source of drinking water for some 1.5 million people in the middle of Texas, including residents of the city of San Antonio. The land is characterized by porous limestone, so that nearly all precipitation seeps directly into the aquifer below. In the Government Canyon area not far from San Antonio, rainfall within a matter of hours increases water pressure at San Antonio's intake wells.

The possibility of development in the Government Canyon area could diminish the quantity of water entering the aquifer and threaten the aquifer's water quality. In the 1980s, a proposal to develop 12,000 acres of Government Canyon hill country was successfully fought by environmentalists all the way to the U.S. Supreme Court. More recently, a project to build 760 homes and a golf course on a 3,200-acre portion of the Government Canyon watershed failed financially and wound up being taken over by the Resolution Trust Corporation (RTC). This time a Government Canyon Coalition that included 40 agencies and organizations sought to find ways to preserve the property. By 1993, RTC agreed to sell the property for $2 million. The Edwards

Aquifer Underground Water District, the San Antonio Water System, and the Texas Parks and Wildlife Department provided the money for the purchase. Since the purchase, the area has experienced two years of drought and the aquifer's level has continued to drop. Water managers believe they need to continue to acquire land to protect the recharge zone.

New York. In 1990, New York City faced a drinking water financial crisis. EPA notified city officials that they must protect their upstate watershed or invest in filtration plants to protect the quality of the 1.5 billion gallons of upstate water used daily. The cost of new filtration plants was estimated at $6 to $8 billion plus annual operating costs of $300 million; with activated carbon technology installed to remove organic materials, construction costs would double and operating costs triple.

Faced with such staggering costs, city officials turned to the watershed protection strategy. City officials devised a three-party watershed protection agreement with the upstate communities that includes land acquisition on a willing-seller basis, revised watershed protection regulations, and direct city investment in upstate water pollution controls.

The city set aside $250 million for land acquisition, initially targeting 80,000 acres of highly sensitive lands. Another $250 million was committed to upgrade all 114 wastewater treatment facilities in the watershed to tertiary treatment standards.

Part of the watershed protection strategy involves the closure of aging septic systems and strict standards for the construction of new systems. The strategy also includes finding alternatives to impervious surfaces—paved roads and parking lots—that are close to reservoirs and watersheds, improved controls for stormwater runoff, and better storage of highway salt.

REBUILDING URBAN WATERFRONTS

In the last few decades, many cities have recognized that decaying urban rivers are potentially valuable natural and economic resources that can provide jobs and help improve economic conditions in an urban area. The success stories in cities such as San Antonio and Chattanooga are by now well-known, yet other cities such as Hartford, Providence, and Pittsburgh have also seized this opportunity.

The Connecticut River, Hartford

For many years residents of the city of Hartford had little opportunity to enjoy the Connecticut River's amenities because of a flood control wall and interstate highway that blocked access to the river. In addition, urban decay had left the riverside area unsafe for recreation and generally unappealing.

In 1981, city officials held a day-long seminar to assess public support for a campaign to make the riverfront area more accessible to the community. Out of this meeting was born Riverfront Recapture, Inc., a nonprofit organization

with a mandate to restore public access and create a riverfront network of parks and recreational facilities. The group's 65-person board includes representatives the city's business community, civic organizations, local and state government, various Hartford neighborhoods, and regional groups.

Two other groups played key roles in the effort. Friends of the River is a grassroots organization with members from some 80 towns across the state. The Connecticut Department of Transportation, which had the responsibility to redesign Highway I-91, also played a key role.

After the 1981 meeting, Riverfront Recapture began soliciting recommendations from the community about how best to revive the waterfront. Some low-income residents worried that the group's efforts would largely benefit the corporate community, but Riverfront Recapture convinced these groups that the redevelopment would provide amenities they would enjoy such as parks and fishing and boating programs.

In 1984, the Connecticut Department of Transportation agreed to restore public access to the riverfront during reconstruction of Highway I-91. A new dock and overlook were constructed along the river, and in 1986 the Connecticut General Assembly authorized funds to Riverfront Recapture for park development. The first two phases of the Great River Park in East Hartford opened in 1987, and in 1988 planning began on a plaza over Highway I-91. In 1989, the first section of the riverwalk system opened. In 1994, construction began on the plan's final phase, which includes riverwalks on both banks and an amphitheater adjacent to Highway I-91. The highway's elevated section was demolished to allow construction on the plaza connecting the downtown area to the river.

Water quality in the river had been gradually improving during the 1980s, though the city still had to contend with occasional combined sewer overflows during heavy rains. In part because of the effort to redevelop the river, Hartford voters in 1990 voted overwhelmingly for an $80 million series of projects designed to dramatically reduce combined sewer overflows to the rivers.

Riverfront Recapture also succeeded in bring people back to the river. The group launched a community boating program in 1988, offering rowing classes to adults for a fee and to teenagers for free. The boating program's success led to a creation of a popular crew club at Hartford High School. Another program, "Get Hooked on Fishing—Not on Drugs," has introduced hundreds of urban youths to the pleasures of fishing along the river. Riverfront Recapture also sponsors a summer youth-employment program that brings low-income Hartford youths to the river to serve as Riverfront Rangers. Some participants planted trees and flowers, while others built boats under the supervision of a local boat builder.

Most of Riverfront Recapture's capital budget is from public sources, including $14.5 million in state funding and $18 million in federal funding. The operating budget is primarily from private funds, including contributions from foundations, individuals, and corporations.

Station Square development on the Monongahela River in Pittsburgh

Photo Credit
Jim Judkis/Pittsburgh History & Landmarks Foundation

Station Square, Pittsburgh

Station Square is situated on the south shore of the Monongahela River in downtown Pittsburgh. In the 19th Century, Station Square was the headquarters of the Pittsburgh and Lake Erie Railroad which specialized in hauling coke, ore, and coal to Pittsburgh's steel mills. Passengers and freight were also part of the railroad's business. To handle a growing volume of passenger business and its central offices, the railroad developed a large terminal in the early 1900s. The site includes 52 acres and over a mile of waterfrontage.

Until recently, Station Square was owned and managed by the Pittsburgh History and Landmarks Foundation, a nonprofit organization. The Foundation has been very active in Pittsburgh for several decades, working to revitalize historic properties, assist inner-city neighborhoods, provide technical assistance to community groups, and survey Allegheny County's historical, architectural, landscape, and industrial resources and complete nominations to the National Register of Historic Places.

In Station Square, the Landmarks Foundation created a lively urban environment by combining the renovation of five historic railroad buildings with new construction. The riverfront location and the improvements in river water quality were vital parts of this development's success.

The project's first phase began in 1976 and concluded in 1992. Two restored railroad warehouses became The Shops

Box 5.3
The Commercial Value of the Riverfront

"In Pittsburgh before Landmarks undertook Station Square in 1975, Pittsburgh's riverfronts were given over to highways and industry only. Although a railroad line still parallels the river at Station Square, Landmarks opened up over a mile of riverfront for people to experience.

"The local population had a growing awareness that the river waters were being cleaned. Ducks were swimming around the banks of Station Square and boaters were registering thousands of pleasure craft to the enjoy the waters. The Gateway Clipper fleet of tourboats moved to Station Square and more than doubled its business. The Sheraton Hotel has enjoyed the highest occupancy in the city for years, in part because of the riverview and in part because of the active, clean environment looking toward the city skyline."

Arthur Ziegler

(Arthur Ziegler is President of the Pittsburgh History and Landmarks Foundation.)

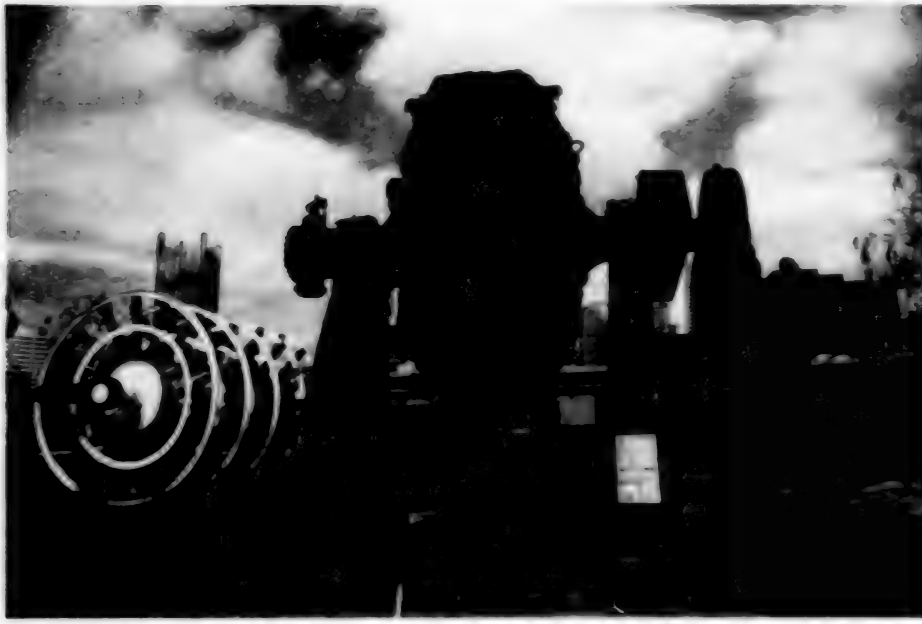
at Station Square, which includes some 70 stores and more than a dozen restaurants. Four major railroad buildings have been renovated into first-class office space, including the Commerce Court built in 1917, the Gatehouse of 1916, and the Landmarks Building, the railroad's passenger terminal built in 1901.

America's largest and most successful excursion-boat operation is headquartered at Station Square. The Gateway Clipper Fleet includes the 1,000-passenger flagship *Majestic* and the 150-passenger *Good Ship Lollipop*.

A Phase II Master Plan was completed and adopted by the city in 1992. An additional 32 acres will be developed in the plan at the western end of the site, including restoration of the historic Lawrence Paint Building of 1897. Riverpark, a two-and-a-half acre site looking out toward the Monongahela and the city skyline, will contain a greensward for outdoor events, sitting areas, and gardens. Adjoining the park will be a terrace restaurant and the Riverwalk of Industrial Artifacts, which includes giant Bessemer converters that celebrate Pittsburgh's industrial history.

Station Square has been a remarkable economic success. It has already created about 3,000 jobs and pays real-estate and income taxes totaling about $6 million annually. About $87 million has been privately invested in the project, and over $12 million has been contributed through philanthropic and public funds. For the second phase, which will require about $150 million in private capital, it is projected that 5,100 construction jobs will be created over the 15-year period, that 2,500 people will be employed by 60 new businesses, and that the annual return to taxing bodies will be an additional $7 million. Two million more visitors are expected to come to Station Square, bringing the total annual visitation to 5 million people. (Box 5.3)

Because the master plan involves entirely new construction, Landmarks sold the project to a major developer interested in building in downtown areas.



Bessemer converters once filled Pittsburgh night skies with fiery light. The last converter stands in Station Square.

Photo Credit
Jim Judkis/Pittsburgh History & Landmarks Foundation

Forest City Enterprises of Cleveland. Under the terms of the sale, Forest City will implement the new development and finance it, with Landmarks continuing to handle daily operations and maintain economic interests. Funds from the sale have assisted in endowing Landmarks' programs.

Waterplace Park and River Relocation Project, Providence

In the late 1970s, Providence officials realized that downtown Providence was the urban equivalent of a Gordian Knot. Elevated rail tracks and parking lots divided the downtown area from the State House and Smith Hill. The Providence River, which flowed between downtown and the city's East Side, was covered over with acres of roadway decking. Crosstown traffic and interstate access ramps converged at the roadway decking and became congested and dangerous because of the highly irregular and poorly defined roadway pattern. Pedestrian circulation under the railroad tracks and across the roadway decking was unpleasant and dangerous.

The effort to redesign the city and reclaim the beauty and usefulness of the city's rivers began in 1979 with a plan that called for relocation of the city's railroad station and tracks, construction of a major downtown interchange at Route I-95 and a boulevard connecting the interchange to the roadway deck over the Providence River, and a 55-acre develop-

ment district to be known as Capital Center. The 1979 plan did not address the decking covering the rivers. It did include plans for a 4-acre "Waterplace" park, but provided no funding for this project.

In 1984, a waterfront study sponsored by the city, state, Providence Foundation, and the National Endowment for the Arts proposed removing the decking and opening up the Providence River. The project, which became known as the River Relocation Project, had four major features. These are:

- Improving and consolidating traffic patterns by extending several roads and building seven new bridges for vehicles and five new bridges dedicated to pedestrians.

- Developing a "Y" shaped landscaped river corridor at the center of the city that connected existing parks, accommodated boat traffic, and created an independent walkway system. This was accomplished by relocating portions of the Woonasquatucket, Moshassuck, and Providence rivers and removing the old bridges and decking that covered one and one-quarter miles of the rivers.

- Dredging the rivers and establishing uniform clearances under the bridges to accommodate boat traffic. Three docking places are provided for boats to discharge and take on passengers.

- Creating "Waterplace," a four-acre park that punctuates the western terminus of the walkway system. The park includes a 30-foot high fountain, an amphitheater, several smaller plazas with seating, two pedestrian bridges, and a pavilion building to accommodate a restaurant and visitors' center.

With the completion of the $50 million project, over 11 acres of urban riverfront parks have been created for the enjoyment of residents and visitors. Boats utilize Waterplace and nearly a mile of downtown river channels. Nearly 1.5 miles of riverwalks are available for pedestrians and joggers.

All told, the city's redevelopment effort has cost about $150 million in public funds, with about three fourths of the total provided by the Federal Railway Administration and Federal Highway Administration. To date, the Capital Center project has generated about $600 million in private investment and created about 4,000 permanent jobs. It is expected to ultimately generate an additional $400 million in private investment and 6,000 more permanent jobs.

The new riverfront amenities and parks have given the city a popular new face. Particularly noteworthy is a new multimedia fire installation by artist Barnaby Evans called "Water Fire Providence." Forty ritual bonfires hover above the surface of the Woonasquatucket River and thread through a half-mile section of Waterplace Park. Created initially as a temporary installation in 1996, Water Fire proved so popular that a community effort has raised funds to bring it back as an ongoing "signature" event for the city. In 1998, the multimedia show was held several times through the summer and attracted some 215,000 people.

LEVERAGING URBAN PROGRESS

An important focal point of national policymaking in recent years has been the effort to devise new ways to encourage the economic revitalization of decaying inner cities.

Many of the nation's older cities have been through a difficult cycle of expansion and contraction in this century. In Detroit, the first Ford Model T rolled off the assembly line in 1913. When Ford announced it would pay $5 per hour for an 8-hour shift – nearly twice the standard wage in the countryside – crowds of workers flocked to the city. Detroit's population rose from 285,000 in 1900 to well over 1 million by 1921 and nearly 2 million by 1950.

In the last two decades, however, Detroit's population dropped by 32 percent and was again around the 1 million mark. The percentage of poor in the city more than doubled over the 1970-90 period. Many social indicators also showed a widening economic gap between cities and suburbs. In Detroit, for example, infant mortality rates widened to some three times higher than the neighboring suburb of Warren.

What happened? The causes are complex. Ironically in the case of Detroit, one of the principal causes was the emergence of the automobile as the dominant mode of transportation, which made industrial expansion into outlying areas relatively easy and gave workers the mobility to drive to those plants. At the same time industries began to use trucks instead of trains to move materials, and freeway construction allowed plants to be located at greater distances from materials.

Suburbs provided open space that was easy to develop, and suburban governments courted industries with tax and infrastructure incentives to encourage such moves. Older inner cities, by comparison, were filled with abandoned buildings and "brownfield" sites – land and buildings possibly contaminated by previous industrial activity that now stood empty. Aside from the costs of removing these structures, companies hesitated to redevelop brownfields because of expensive cleanup regulations.

The experience in Detroit was mirrored in many other cities across the nation, prompting an intense new effort to find ways to redress the suburban-urban gap. Two approaches – empowerment zones and brownfields redevelopment – have emerged as promising approaches.

Empowerment Zones

Started in December 1994, the Clinton Administration's Empowerment Zone and Enterprise Community Initiative provides tax incentives and performance grants and loans to 72 urban areas and 33 rural communities across the nation. All told, these communities are receiving more than $1.5 billion in performance grants and more than $2.5 billion in tax incentives. Private investments amount to about $1.5 billion.

The communities were nominated by state and local governments; each area met eligibility requirements related to population, distress, size, and poverty

state. The designations remain in effect for 10 years.

Each urban Empowerment Zone (EZ) received $100 million and each rural zone received $40 million in performance grants for job creation and job-related activities. The urban EZs are Atlanta, Baltimore, Chicago, Detroit, New York, and Philadelphia/Camden. The rural EZs are Kentucky Highlands, Mississippi Delta, and Rio Grande Valley. As Supplemental Empowerment Zones, Los Angeles received a grant of $125 million and Cleveland received $90 million. Boston, Houston, Kansas City, and Oakland each received $25 million as Enhanced Enterprise Communities. The remaining 95 urban and rural areas received $3 million. As a result of the Taxpayer Relief Act of 1997, Cleveland and Los Angeles became Empowerment Zones in the year 2000.

Employers in the urban and rural empowerment zones are eligible for up to $3,000 in wage tax credits for every employee who lives and works in the Empowerment Zone. EZ businesses also are eligible for increased tax expensing for purchases of buildings, plant and equipment. All of the 105 zones and communities are eligible to receive tax-exempt bond financing that offers lower rates than conventional financing to finance business property and land, renovations, or expansions.

With the help of past experience gained in federal programs and some of the 37 state enterprise zone programs, the EZ/EC Initiative seeks to combine targeted tax incentives with direct financial assistance, job readiness training and placement services, improvements to physical infrastructure and public safety, and the development of strong community partnerships. It is designed to encourage community involvement and better coordination among elected local, state, and federal officials.

To date, studies suggest that the level of citizen participation that occurred during development of each city's strategic plan has been significantly greater than under previous federal initiatives, that outreach was more extensive, and that a wide variety of community stakeholders were involved in the planning process.

Though not the major focus of the effort, environmental initiatives are nevertheless an important part of the mix. For example:

- In the Atlanta Empowerment Zone, "Renewal Atlanta" is a new recycling business established on a former industrial site that will create up to 65 full-time jobs for EZ residents and 200 temporary jobs for youth. The company will offer EZ youth up to 2-year internships in various recycling enterprises, with interns earning stipends of $4,000 for each year in the program.
- In the Baltimore EZ, the Baltimore Development Corporation is establishing an eco-industrial park to make use of more than 1,200 acres of underutilized land. A minimum of 10 new businesses are being sought for the park. The Park will attempt to ensure environmentally sound industrial development by matching businesses that can make productive use of one another's waste materials. When the

project reaches its full potential, 1,500 jobs will be available to EZ residents.

- In the Atlanta EZ, a partnership that includes the city, U.S. EPA, and several private firms is distributing free of charge about 3,000 ultra-low-flush toilets and low-flow showerheads to EZ residents. The project could save participating EZ residents about $120 annually on their water bill and reduce overall water consumption by about 25 million gallons.

- In the Minneapolis Enterprise Community, the Green Institute ReUse Center sells used materials donated by individual do-it-yourselfers or contractors and manufacturers. The goal is to encourage economical homeownership improvements while saving and reusing materials, and reducing the amount of discarded building materials entering the city's solid waste stream.

- In the St. Louis Enterprise Community, a community greening program assists neighborhood groups in implementing greening projects such as planting trees, flowerbeds, neighborhood entrances, and vacant lots.

- In the San Diego EC, Operation Embrace is working in the Barrio Logan community, which is badly blighted by gang graffiti. Community youth and adults form Neighborhood Watch groups to identify increases in graffiti and areas where ivy could be planted to cover it. Ivy planting is an effective alternative to painting because it eliminates the need for additional painting.

- In the Tampa EC, the Neighborhood Environmental Action Team (NEAT) educates the community on methods for reducing graffiti such as the installation of thorny shrubs, drought-tolerant plants, vines, textured walls and murals, and techniques on ways to remove graffiti. NEAT also trains, equips, and hires 16- to 21-year-old youth from the EC to remove weeds, mow, caulk, lay cold asphalt, remove graffiti, and install graffiti-prevention methods.

Many federal agencies are trying to find creative new ways to apply their program resources to Empowerment Zones and Enterprise Communities. For example, the National Park Service's Rivers, Trails, and Conservation Assistance program works with communities nationwide to help them protect their rivers, trails, and greenways. The program provides technical assistance to citizens groups and all levels of government to facilitate community-based conservation. Examples include:

- In Milwaukee, many residents and community-based organizations within Milwaukee's enterprise community are involved in the South Side conceptual plan for an eight-mile urban greenway and recreational corridor through the Menomonee River Valley. The greenway will connect Lake Michigan shoreline parks and downtown Milwaukee with the western suburbs.

- In Seattle, the program provided a $40,000 partnership grant in 1998 for the Duwamish Youth Initiative, a student ambassador program that focuses on improving the Green/Duwamish

watershed. The objective is to recruit more than 200 young people, perform 20,000 hours of watershed restoration and community revitalization service, offer leadership training, career development, and mentoring services to youth, and certify more than 100 "Duwamish Ambassadors" to recruit and train other residents.

- In Detroit, the program has actively supported the Detroit River Greenway Partnership, in which over 25 community and government organizations are working to improve and restore 37 miles of the Detroit River and its waterfront resources.

As a result of the Taxpayer Relief Act of 1997, an additional 20 Empowerment Zones will be designated before January 1, 1999 and remain in effect for 10 years. No more than 15 of the Second-Round Empowerment Zones are to be located in urban areas and no more than five in rural areas. The present law geographic and poverty eligibility criteria are expanded slightly for these new zones; in particular, the zones are expanded to include developable sites that are 2,000 acres but not subject to the poverty rate criteria. Within the 20 new zones, qualified enterprise zone businesses are eligible to receive increased expensing (except in the developable sites), brownfields remediation expense current deductions, and benefits from tax-exempt bond financing outside the State private activity bond caps.

Historic Rehabilitation tax credits, which provide a 20 percent tax credit for the rehabilitation of certain historic buildings to National Park Service standards, are another valuable contributor to urban restoration projects. The Interior Department can work with state and local governments to identify eligible historic districts, to provide information to Empowerment Zones and Enterprise Communities about the uses of the tax credit program, and to facilitate certification of rehabilitation programs within Empowerment Zones and Enterprise Communities.

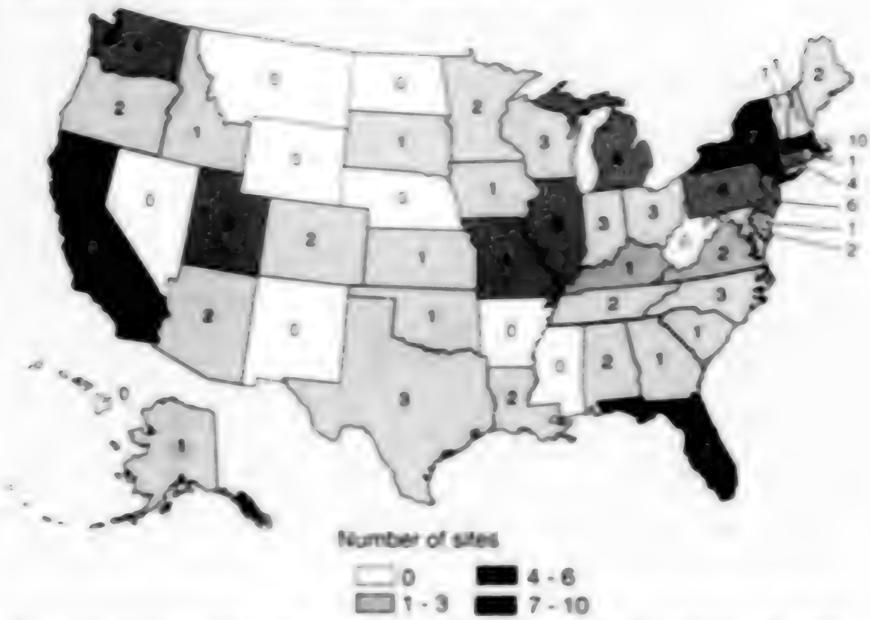
Since 1977, the program has generated over $17 billion in historic preservation activity, representing rehabilitation work on more than 26,000 historic buildings. In Denver, for example, six of the city's 27 historic districts lie wholly or partially within the boundaries of the city's current Enterprise Communities. All told, these districts include well over 940 individual properties. Any historic income-producing property (commercial, industrial, and rental residential) within these districts would qualify for the tax credit program.

Brownfields

In communities all around the country lie thousands of old, abandoned industrial sites—old steel mills in western Pennsylvania and Chicago's southeast side, dry cleaning plants, metal plating and machine shops, and chemical plants.

These "brownfield" sites—perhaps as many as 450,000 across the nation—are a potent symbol of decay and economic stagnation. Many seem to be golden opportunities for redevelopment and revitalization. Yet the possibility that the

Figure 5.11 EPA Brownfield Pilots by State, June 1997



Source: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, *Brownfield Pilot Locations* (an internet accessible report), June 1997

buildings, equipment or surrounding land might be contaminated as a result of past industrial practices presents a real barrier to redevelopment. Lenders, developers, and investors are all afraid that getting involved with these sites might result in liability for contamination they did not create.

Faced with these legal uncertainties, many developers opt for suburban "greenfields," which require more investment in infrastructure such as sewers and roads but are much less risky than sites requiring cleanup. The tendency to choose greenfields over brownfields means lost employment opportunities for city residents, lost tax revenue for city governments, and more suburban sprawl.

About 1,400 sites are real environmental nightmares that have been placed on the Superfund's National Priority List. Thousands of other sites are only lightly contaminated, yet still present many of the same legal uncertainties. To begin dealing with this problem, EPA has removed more than 31,000 of the sites listed in the inventory of potential Superfund sites. EPA anticipates no further action under the federal Superfund program at these sites.

Increasingly aware of this barrier to revitalization, many mayors and community organizations are pressing the federal

government to find ways to safely expedite the redevelopment of urban brownfields. The National Conference of Mayors has identified brownfields as the number one environmental issue in the nation.

EPA's Brownfields Economic Redevelopment Initiative is designed to help communities revitalize brownfields both environmentally and economically and to mitigate potential health risks. It has four components: providing grants for brownfields pilot projects, clarifying liability and cleanup issues, building partnerships and outreach among federal agencies, states, tribes, municipalities, and communities, and fostering local job development and training initiatives.

The brownfields assessment pilots—each funded at up to $200,000 over two years—test cleanup and redevelopment planning models, assess the removal of regulatory barriers without sacrificing protectiveness, and encourage coordination at the federal, state, and local levels. Through June 1997, EPA has provided funding to states, cities, towns, counties, and tribes for 115 brownfields assessment pilots (Figure 5.11). For example:

- In Astoria, Oregon, the city is working with the state and community groups to clean up an abandoned plywood mill site and transform it into a thriving waterfront property. Located adjacent to downtown Astoria's historic area, where the mouth of the Columbia spills into the Pacific Ocean, the former industrial property will soon house a public promenade, shops, and residential housing.
- In Trenton, New Jersey, city officials are working to redevelop a site that was home to commercial lead-acid battery manufacturers from the 1930s to the 1980s, and then host to a manufacturer of felt-tip pens until the company filed for bankruptcy and abandoned the site in 1989. The city is experimenting with a new soil clean-up technique called *phytoremediation*, in which plants such as Indian Mustard are used to extract lead and other heavy metals from the ground. Following an initial planting of Indian Mustard in April 1996, tests show that lead levels on the property have already been reduced.
- In Emeryville, California, some 230 acres of former heavy industry and research sites now lie vacant or underused, with 215 acres known to have soil and groundwater contamination. EPA and city officials are working to rejuvenate the area, targeting 10 sites and more than 150 acres for redevelopment. Cutting-edge technology companies plan to return to the area. The city also plans to create recreational parks to replace the abandoned lots that have long been eyesores for the community.

EPA has issued several guidances and policies that seek to clarify and eliminate liability concerns at contaminated properties. For example, EPA's "Policy for Owners of Property Containing Contaminated Aquifers" reassures landowners that EPA does not plan to sue them for groundwater contamination if they did

not cause or contribute to the contamination.

EPA also has issued guidance that states the conditions under which EPA will not sue prospective purchasers for contamination that existed before the purchase; issued a policy on the use of "Comfort" letters that describe EPA's intent to exercise its response and enforcement authorities under Superfund at a particular property based on currently known information; and issued soil-screening guidance to help decision-makers quickly determine which portions of a site require further study.

In May 1997, Vice President Gore announced that 15 federal agencies have committed over $300 million over two years plus an additional $165 million in loan guarantees to support the Brownfields National Partnership Action Agenda, an expansion of the original initiative. All told, the project could help clean up as many as 5,000 properties, leverage from $5 billion to $28 billion in private investment and support the creation of up to 196,000 jobs.

Many other federal agencies are involved in the effort to expedite brownfields redevelopment. For example:

- The Department of Housing and Urban Development (HUD) is providing assistance in community development and housing support and up to $165 million in loan guarantees. HUD is revising Community Development Block Grant regulations to encourage use of funds for brownfields redevelopment.

- The Economic Development Administration (EDA) is supporting brownfields redevelopment in distressed areas.

- The National Oceanic and Atmospheric Administration (NOAA) is providing assistance for waterfront and coastal revitalization.

- The Department of Health and Human Services (HHS) is leading an administration effort to develop a public health policy for brownfields to protect community residents.

- The General Services Administration (GSA) is conducting environmental surveys on federal properties to expedite brownfields development.

The partnership has selected applications from communities to serve as "Brownfields Showcase Communities"—models demonstrating the benefits of collaborative activity on brownfields. More than 200 communities responded to the proposal, and 40 communities were chosen as finalists and asked to submit detailed applications by December 10, 1997. The Showcase communities will receive a mix of technical and financial support depending on their specific needs and will develop models of cooperation that can be copied across the country.

In general, unless the taxpayer contaminated the land, brownfields remediation expenses are not currently deductible but must be capitalized. In the Taxpayer Relief Act of 1997, Congress extended current deductibility to qualified environmental remediation expenditures. These are expenditures that would otherwise be capitalized and are paid or incurred in connection with the

abatement or control of hazardous substances at a qualified contaminated site. A qualified contaminated site must be within a targeted area, i.e., census tracts with at least 20 percent poverty rates, current and second-round Empowerment Zones and Enterprise Communities, and the 76 designated EPA Brownfields Pilot projects. Current deductibility is available for qualified environmental remediation expenditures paid or incurred after August 5, 1997, and before January 1, 2001. In order to claim a deduction, the taxpayer must obtain a statement from a designated State environmental agency that the qualified contaminated site satisfies the statutory geographic and contamination requirements.

NEW APPROACHES TO URBAN GROWTH

In the spring of 1994 a "public committee" of community, industry, and environmental leaders began a three-year project to characterize and rank environmental problems in the greater Cleveland area, set environmental priorities for the region, and develop new approaches to address environmental problems.

After getting input from a variety of organizations, the group was asked to rank 16 environmental problems in terms of risks to public health, ecological resources, and other quality of life aspects. The problems included surface water and groundwater quality, indoor and outdoor air quality, acid rain, stratospheric ozone loss and global warming, quality of natural areas, environmental and economic impacts of outmigration from the urban core, solid waste disposal, and others.

In the course of these deliberations, members of the committee realized that many of these problems were directly or indirectly driven by urban sprawl. This insight led to a decision that urban sprawl should take priority as the "umbrella issue" for the implementation phase of the project.

Like this committee in Cleveland, many other groups have been rethinking the costs and benefits of urban development. In many regions, studies found that new growth was typified by new housing developments encroaching farther into agricultural and environmentally sensitive lands, an increasing dependence on automobiles, and the isolation of central cities and older communities.

Between 1970 and 1990, cities like Chicago and Philadelphia grew by more than 30 percent in land use but less than 5 percent in population. Between 1960 and 1990, the overall population in the Kansas City metropolitan area grew by less than one third, while the developed land area doubled.

Many factors have pushed urban development in this direction. Suburban communities often offer lower crime rates and greater access to skilled labor than many central cities. In addition, suburban community officials have provided tax breaks, public infrastructure, and other incentives to lure commercial and industrial employers from the urban core. Federal tax dollars have been frequently used to construct beltways

around urban areas that encouraged suburban development. Tax provisions, such as the preferential treatment of housing capital gains and the deductibility of home mortgage interest, lead to more housing investment than would occur without the current preferential tax treatment.

Many studies over the past few decades have questioned the wisdom of this growth pattern, noting that new suburban residents often demanded more in government services than they paid in taxes, that growing use of automobiles meant increasing traffic congestion and air pollution, that older inner cities were losing jobs and being left behind, and that farmers and small residential communities were being swallowed up by urban sprawl.

In response, many states and communities have been trying to develop new approaches. For example, residents of Portland, Oregon, elected a regional government with broad powers to carry out a regional vision and a more conscious effort to direct regional growth and development.

The key elements in Portland's success include: encouraging intensive development near transit; requiring development at a pedestrian scale with a mix of uses; limiting commuter parking; investing heavily in transit; and creating an Urban Growth Boundary that defines urban and rural areas.

Portland has made a deliberate decision to invest in transit rather than new road capacity. No new road capacity has been added to the downtown area for 20 years. In addition, the city removed a six-lane expressway to create a downtown riverfront park, and shifted money designated for two new freeways into new transit construction.

Portland has worked closely with the Tri-Met, the Portland Transit Authority, to coordinate land use with transportation and encourage cluster development next to the new MAX subway line. Voters have twice approved measures expanding the light-rail system from 15 to 58 miles. Over $1.3 billion worth of development is under construction or completed adjacent to the MAX since the decision to expand the line, and plans have been announced for another $440 million worth of improvements. The transit line also is credited with accelerating historic renovations, influencing the design of office buildings, and helping to make new retail development feasible.

The city's vision of its future seems to be a success. Downtown employment has grown from 50,000 jobs in 1975 to 105,000 jobs today. Air quality violations have improved from over 100 annually in the 1970s to no violations since 1987. Portland has added no additional parking spaces downtown, and over 50 percent of downtown trips are taken on the transit system.

Growing Smart

In many regions, coalitions of developers, environmentalists, citizens, and government officials are getting together to think about new approaches to growth and development.

One of the most dynamic examples is Maryland's Smart Growth Initiative. The

initiative was built on the Maryland Economic Growth, Resource Protection, and Planning Act of 1992, and further strengthened in 1997 with enactment of the Neighborhood Conservation and Smart Growth package of initiatives.

Maryland's approach was built from seven widely accepted "visions" that were part of the regional Chesapeake Bay Agreement. These visions, intended to guide Maryland's future development, are:

- Development is concentrated in suitable areas.
- Sensitive areas are protected.
- In rural areas, growth is directed to existing population centers and resource areas are protected.
- Stewardship of the Chesapeake Bay and the land is a universal ethic.
- Conservation of resources, including a reduction in resource consumption, is practiced.
- To assure the achievement of 1 through 5 above, economic growth is encouraged and regulatory mechanisms are streamlined.
- Funding mechanisms are addressed to achieve these visions.

The centerpiece of the 1997 package is the "Smart Growth Areas" legislation. This new law limits most State spending on housing, infrastructure, economic development, and other programs to "Priority Funding Areas," which are areas that local governments determine are suitable for further growth. This serves to channel state funds to already developed areas and to areas selected by local governments for further growth, while restricting State funding for infrastructure or development in other rural areas.

To encourage economic development and help stabilize older developed areas, the Smart Growth Initiative also facilitates the re-use of brownfields and provides tax credits to businesses creating jobs in a Priority Funding Area. A new "Live Near Your Work" pilot program provides cash contributions to workers buying homes in certain older neighborhoods.

To spur more preservation of undeveloped land, a new "Rural Legacy" program provides financial resources for the protection of farm and forest lands and the conservation of these essential rural resources.

In a proposed federal rule on stormwater management, EPA is asking for ideas on how the agency could create incentives that would encourage local governments to use Smart Growth programs as a way to ease stormwater run-off pollution in urban watersheds. This is the first time that EPA has attempted to reward smarter land use and development practices with less burdensome regulation.

Under the proposed rule, EPA is considering approaches that would provide incentives for local decisionmaking that would limit the adverse water quality impact associated with uncontrolled growth in a watershed. In situations where there are special controls or incentives (e.g., transferable development rights, traditional neighborhood development ordinances) in place directing development toward compact/mixed use

development and away from wetlands, open space, or other protected lands, EPA is considering providing some relief to municipalities. The relief would pertain to minimum control measures concerning construction and new infill development or redevelopment.

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186

CHAPTER SIX

River's End

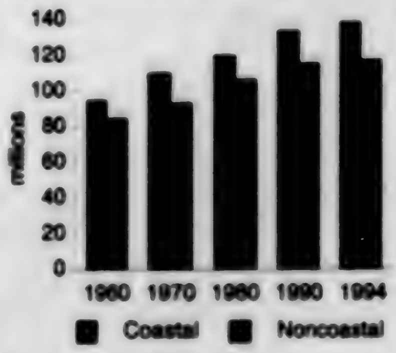
The meeting of rivers with coastal estuaries and the sea marks the end of a journey, yet in American history these locations also mark a beginning—the earliest settlements at the beginning of the nation's history. Some of these settlements grew to become the nation's largest cities. The ports of Boston, New York, Philadelphia, New Orleans and others have rich histories as centers of waterborne commerce.

Today, America's coastal areas support the country's major population centers, much industrial activity, burgeoning retirement and "second home" communities, and popular tourist attractions. Population growth and development pressures in coastal areas often lead to changing and sometimes conflicting land uses; pressures and demands for infrastructure and services; increased pollutant discharges from point and nonpoint sources; and diminution of coastal habitats and aquatic resources. (For a definition of coastal area, see Part III, Table 1.7.)

The coastal regions of the U.S. represent only about one fourth of total U.S. land area, yet the Bureau of the Census estimates that in 1994 roughly 53 percent of the total U.S. population—nearly 140 million people—were living within coastal areas (Figure 6.1). Coastal corridor densities range from 69 people per square mile along the Pacific coast to over 410 people per square mile along the Atlantic coast (Figure 6.2). The U.S. coastal population increased by about 44 million people from 1960 to 1994, slightly more than half the total U.S. population increase. In several small New England states, the entire state population lives within the coastal zone (Figure 6.3).

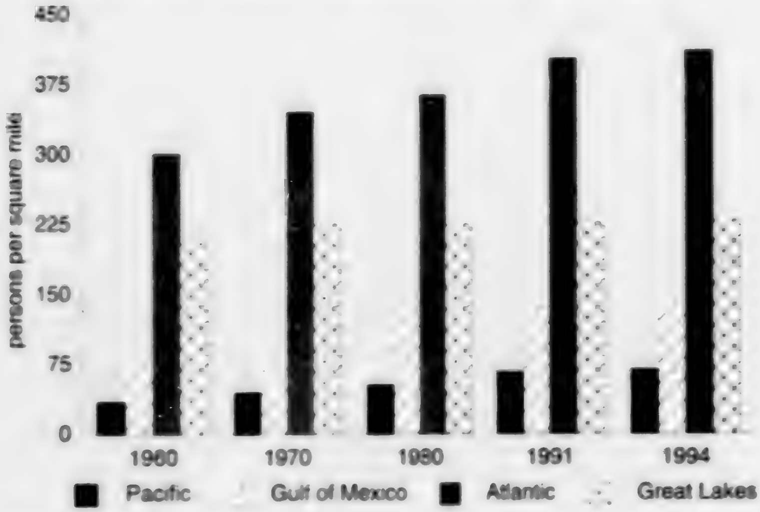
Population growth, both the traditional expansion from cities characteristic of the Northeastern and Mid-Atlantic areas and the suburban sprawl common in the South and Gulf of Mexico, will continue.

Figure 6.1 U.S. Population by Coastal and Noncoastal Place of Residence, 1960-1994



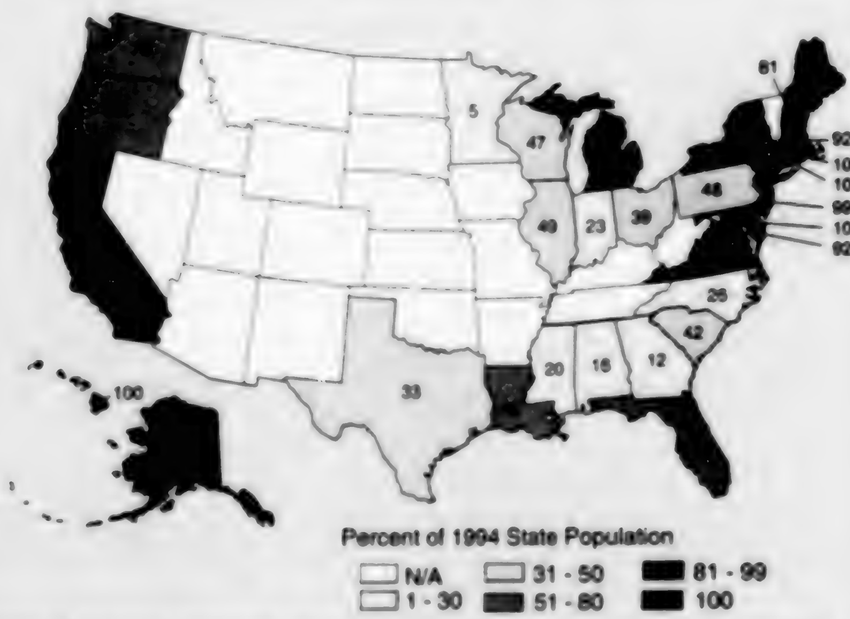
Source: See Part III, Table 1.7.

Figure 6.2 U.S. Coastal Population Density, 1960-1994



Source: See Part III, Table 1.7

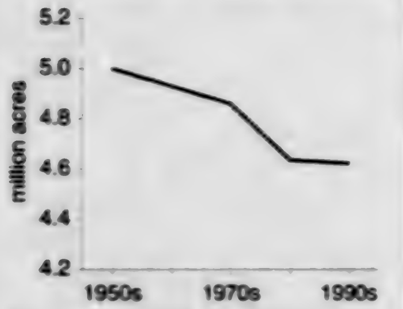
Figure 6.3 Percentage of State Population Living in the Coastal Zone, 1994



Source: U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States* (GPO, Washington, DC, 1997); data from the 1990 Census of Population and Housing, and updates by agency.

Note: N/A = Not applicable.

Figure 6.4 U.S. Coastal Vegetated Wetlands, 1950s to 1990s



Source: Dahl, T.E. et. al., *Status and Trends of Wetlands in the Conterminous United States, 1980s to 1990s* (DOI, FWS, Washington, DC, Draft).

In eastern Florida alone, population per shoreline mile is expected to increase nearly 30 percent by 2010.

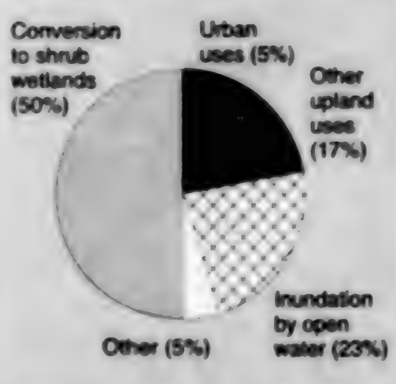
According to a recent study by the National Wetlands Inventory, coastal wetlands continue to decrease in area, although the rate of decline has slowed considerably from earlier periods (Figure 6.4). Urban development, residential and recreational development in rural areas, silvaculture, and erosion were responsible for the losses (Figure 6.5). These losses are particularly significant because of the vital role these coastal habitats play in supporting productive fish and shellfish resources (Box 6.1).

Wetlands losses in Louisiana—estimated at about 24,000 acres annually in the 1978-90 period—are the largest of any state and accounted for two thirds of the nation's total loss in this period. Much of the loss is due to altered hydrology stemming from navigation, flood control, and mineral extraction and transport projects. In the northern Gulf of Mexico, losses of seagrass have also been extensive over the last five decades—from 20 to 100 percent for most estuaries—largely because of coastal population growth and accompanying deterioration of water quality.

Some portion of wetland and seagrass bed losses are attributable to natural processes such as hurricanes and coastal storms. Rising sea level and coastal subsidence—natural processes that are probably accelerated by human activities—are also causing coastal habitat losses. For example, more than half of the coastal marsh acreage lost in Texas between 1955 and 1992 was due to land subsidence and submergence (drowning), which resulted from withdrawal of underground water, oil, and gas (Figure 6.6).

In Boston Harbor, eelgrass beds were abundant just before the turn of the century, but by 1990 only a few beds remained in the remotest parts of the harbor. Probable causes of the decline

Figure 6.5 Loss of U.S. Coastal Marshes by Cause, 1985-1995



Source: Dahl, T.E. et. al., *Status and Trends of Wetlands in the Conterminous United States, 1980s to 1990s* (DOI, FWS, Washington, DC, Draft).
Note: Total loss = 32,000 acres.

Box 6.1
Fish and Shellfish Conditions

In 1996, 2,193 fish consumption advisories were reported by states to EPA (Box Figure 6.1). The number of advisories rose by 453 in 1996, representing a 26 percent increase over 1995. The number of waterbodies under advisory represents 15 percent of the Nation's total lake acres and 5 percent of the Nation's total river miles. In addition, 100 percent of the Great Lakes waters and their connecting waters and a large portion of the Nation's coastal waters were also under advisory. States typically issue five major types of advisories and bans to protect both the general population and specific subpopulations (usually pregnant women, nursing mothers, and young children). All types of advisories increased in number from 1993 to 1996. Box Figure 6.2 shows the number of advisories in the United States for four major contaminants (mercury, PCBs, chlordane, and DDT).

In its National Status and Trends Program, the National Oceanic and Atmospheric Administration (NOAA) measures trace metals and synthetic organic compounds at about 100 sites nationwide and contaminants in mussel and oyster tissues and coastal sediments at about 240 sites nationwide. Not surprisingly, both projects have found that the highest concentrations are near urban and industrial areas. The highest concentrations of chemicals in fish livers are near urbanized areas in the Northeast (New York City, Boston, and Baltimore) and the West (San Diego, Los Angeles, and Seattle). The highest concentrations of organic contaminants in molluscan tissues are at urban sites near Boston, New York City, Mobile, San Diego, San Francisco, and Los Angeles.

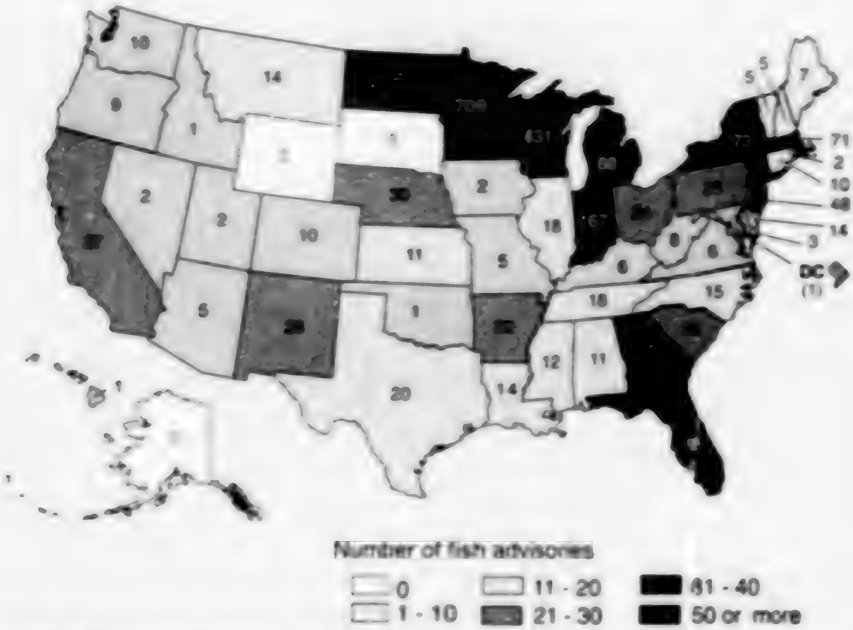
Based on acute toxicity measurements, about 10 percent of the nation's coastal regions are environmentally degraded. The extent of environmental degradation ranges from none in generally pristine environments such as Apalachicola Bay in Florida to 85 percent in the relatively small but heavily contaminated Newark Bay. Approximately 50 percent of coastal regions show adverse biological responses to environmental contaminants.

In its National Shellfish Register of Classified Growing Waters, NOAA conducts surveys of shellfish-growing waters in 122 estuarine and 98 non-estuarine areas (4,230 individual shellfish growing areas) in 21 coastal states. Shellfish-growing areas are classified as approved or "harvest-limited" (including areas that are either conditionally approved, restricted, conditionally restricted, or prohibited).

Over the period from the first report in 1966 to the latest report in 1995, the acreage of classified shellfish-growing waters has increased more than twofold, from 10 million to over 24 million acres. The increase is due primarily to a rise in the number of states classifying non-estuarine waters. The total area of approved waters is at an all-time high of 14.8 million acres (59 percent of all classified waters) (Box Figure 6.3). There were only 2.8 million acres of prohibited waters (13 percent of all classified waters). This is the lowest total of prohibited waters since the 1966 report, and the first time that the percentage of prohibited waters has been below 20 percent.

include decreased water clarity, the growth of algae on eelgrass leaves, and disease. With the expected improvements in water clarity, decreased nitrogen, and reduced algae expected in the harbor in the next few years, eelgrass beds could recover. But the recovery is likely to take decades unless artificial transplanting programs are implemented in the harbor.

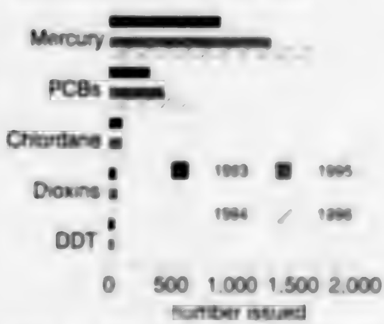
Box Figure 6.1 Number of Fish Consumption Advisories Issued by State, 1996



Source: U.S. Environmental Protection Agency, Office of Water, *Update: National Listing of Fish and Wildlife Consumption Advisories*. Fact Sheet (EPA, OW, Washington, DC, 1997).

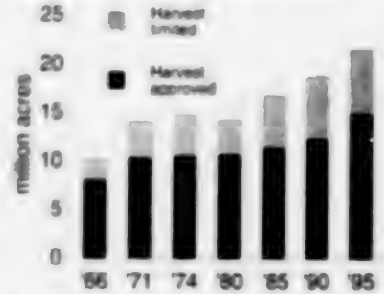
Note: The numbers depicted here do not necessarily reflect the geographic extent of chemical contamination in each state nor the extent of state monitoring efforts.

Box Figure 6.2 Fish Consumption Advisories, 1993-1996



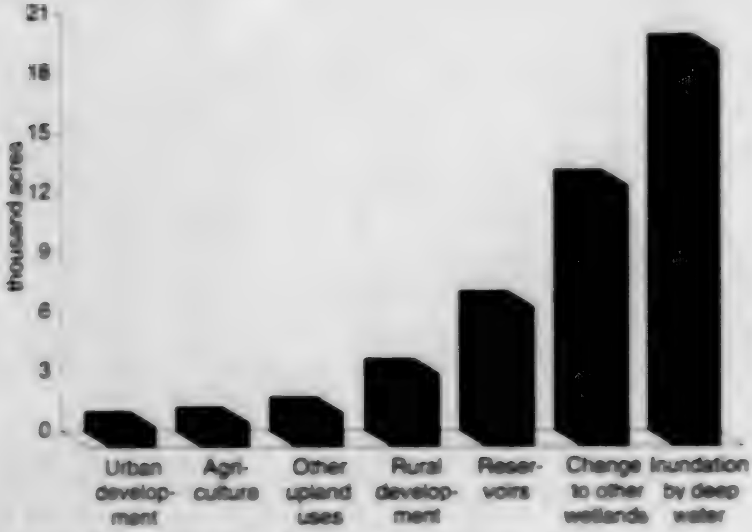
Source: U.S. Environmental Protection Agency, Office of Water, *Update: National Listing of Fish and Wildlife Consumption Advisories*. Fact Sheet (EPA, OW, Washington, DC, 1997).

Box Figure 6.3 Classified U.S. Shellfish Waters, 1966-1995



Source: National Oceanic and Atmospheric Administration, *The 1995 National Shellfish Register of Classified Growing Waters* (NOAA, Silver Spring, MD, 1997).
Note: Harvest limited = sum of conditionally approved, restricted, conditionally restricted, and prohibited.

Figure 6.6 Loss of Coastal Marshes in Texas by Cause, 1955 to 1992



Source: Moulton, D.W. et al., *Texas Coastal Wetlands: Status and Trends, Mid-1950s to Early 1990s* (DOI, FWS, Albuquerque, NM, 1997).

Note: Total loss = 47,900 acres.

COASTAL DEVELOPMENT PRESSURES

Between 1970 and 1989, almost half of all U.S. building construction occurred in coastal regions (Figure 6.7). Florida and California far outpaced other states in all types of coastal construction (Figure 6.8).

Until recently, coastal development has been relatively uncontrolled. For example, many communities permitted coastal wetlands to be filled for housing developments and their waters to be directed into channels. Local governments often overlooked master land-use plans in making decisions on zoning, building permits, and public works projects. In Florida's metropolitan Dade County, which includes Miami, county commissions developed a sewer plan for the entire county as early as 1961, yet the county continued to allow septic tanks and the kind of urban sprawl that the master plan regarded as undesirable until the mid- to-late 1960s.

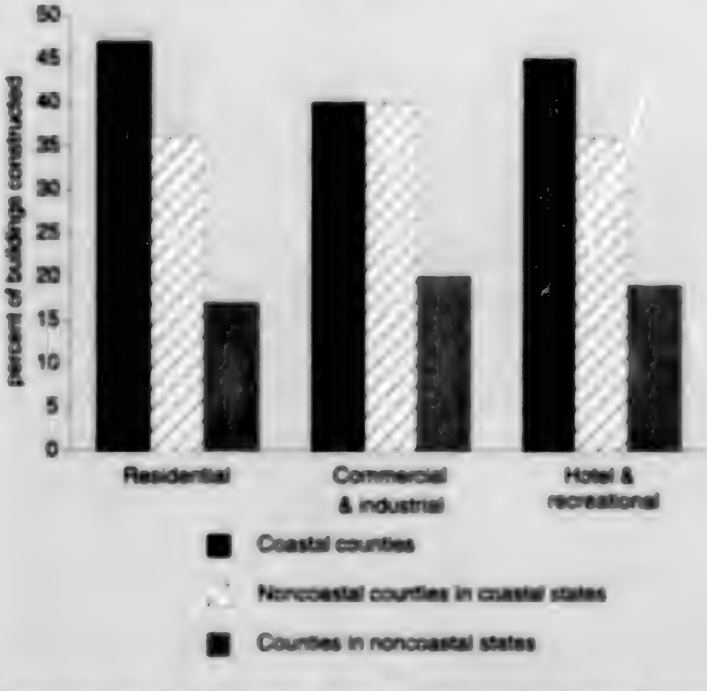
By the mid-1970s, local support was building for controlling growth and keeping development from exceeding the carrying capacity of natural systems. In Dade County, for example, local conservationists protested a proposal to build a new town with as many as 250,000 people along south Biscayne Bay. The plan ultimately approved by the county limited population to 51,000 and excluded all development along the Bay except for a marina.

Florida's massive growth in the 1970s and 1980s finally led the state to adopt a comprehensive growth management system in 1984-86. It required development to proceed on a "pay-as-you-go" basis, which meant building infrastructure to support new development. The state government also attempted to combat urban sprawl, developing policies that promoted redevelopment and the use of existing urban infrastructure.

Similar pressures were building in other states. For example, Maryland enacted the Chesapeake Bay Critical Area Protection Law, which limits development in areas within 1,000 feet of tidal waters or 1,000 feet from the landward side of tidal wetlands. Maryland's new "Smart Growth" law, which is described in Chapter Five, also helps protect undeveloped coastal areas.

At the national level, Congress recognized the need to balance protection of estuarine health with economic growth by establishing the National Estuary Program (NEP) as part of the 1987 amendments to the Clean Water Act. The Environmental Protection Agency oversees

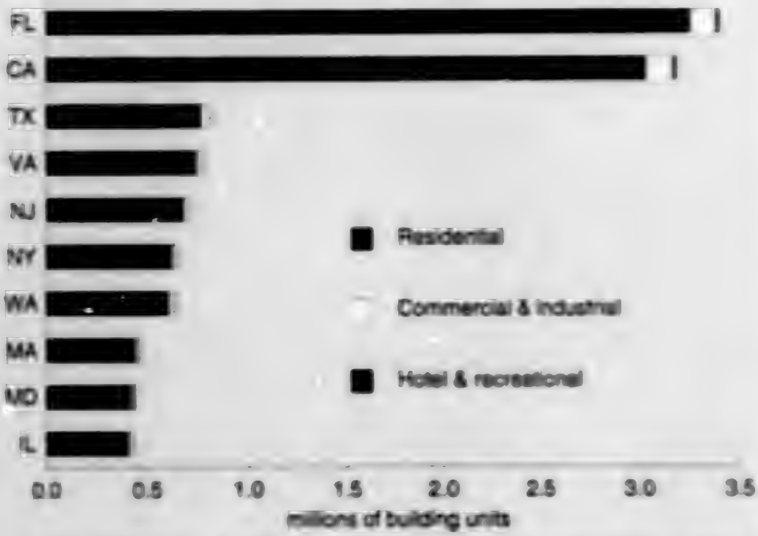
Figure 6.7 Distribution of Building Construction in Coastal and Noncoastal Counties by Type, 1970-1989



Source: Culliton, T.J. et al., *Building Along America's Coast: 20 Years of Building Permits, 1970-89* (DOC, NOAA, Rockville, MD, 1992).

Note: Percentages are based on the following totals: residential, 28,742,682 units; commercial and industrial, 1,597,980 units; and hotel and recreational, 148,142 units.

Figure 6.8 Ten Leading States in Coastal Construction Authorized by Permit, 1979-1989



Source: Culliton, T.J. et al., *Building Along America's Coast: 20 Years of Building Permits, 1970-89* (DOC, NOAA, Rockville, MD, 1992)

the NEP, which currently includes 28 estuaries around the country. Each estuary program involves building a partnership between government agencies and the citizens and businesses in the estuarine watershed. These partnerships develop and implement management plans for protecting and restoring the estuaries, while taking into consideration economic and recreational demands. The NEP serves as a model for all coastal watersheds and for coastal communities taking a partnership approach to managing their estuarine resources.

Development on coastal barrier islands—the long, narrow spits of beach that lie along much of the east coast—has slowed significantly in recent years, in part because of a major change in federal policy.

By 1980, half of the nation's 280 coastal barrier islands were at least partially developed, 70 heavily so. Barrier island structures were often badly damaged by hurricanes and other storms, and then rebuilt. Between 1978 and 1987, about $1 billion, much of it in federal funds, went to reconstructing previously damaged areas. This unproductive cycle has slowed since 1982, when Congress agreed to eliminate federal subsidies perpetuating this destruction-reconstruction cycle. While the Coastal Barrier Resources Act (COBRA) does not bar private development, withdrawal of the subsidies makes development much less likely.

Box 6.2
Water Quality in Coasts and Estuaries

Of the 72 percent of the nation's estuarine waters surveyed, EPA's 1996 *National Water Quality Inventory* found that 58 percent were fully supporting their designated uses, 38 percent were impaired, and 4 percent were threatened (Box Figure 6.4). The most widespread causes of impairment were nutrients and bacteria, which affected about half of the impaired area (Box Figure 6.5). Oxygen depletion from organic wastes, habitat alteration, oil and grease, toxic chemicals, and metals also were significant environmental problems. Urban runoff, including CSOs, discharge from municipal and industrial sewage treatment plants, and agricultural runoff were significant sources of pollution (Box Figure 6.6).

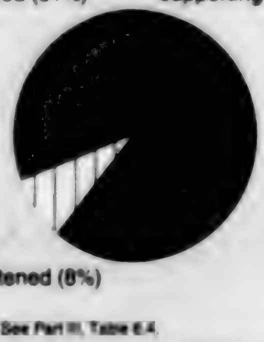
Long-term survey data by the U.S. Geological Survey show that coastal erosion is affecting each of the 30 coastal states. About 80 percent of U.S. coastal barrier islands are undergoing net long-term erosion at rates ranging from less than 3.3 feet to as much as 65 feet per year. Natural processes such as storms may be the precipitating cause of this erosion, but human activities such as mineral extraction, commercial and residential development, shoreline barrier construction, beach nourishment, and dredging are recognized as having major effects on shoreline stability. Rising sea level is also implicated in the erosion of barrier islands.

COASTAL WATER QUALITY

Water quality continues to affect the safety and utility of the nation's ocean, bay, and Great Lakes beach water (Box 6.2). In 1996, according to a survey conducted by the Natural Resources Defense Council, there were at least 2,596 individual closings and advisories, 16 extended closings that lasted 6-12 weeks, and 20 "permanent" closings that lasted over 12 weeks.

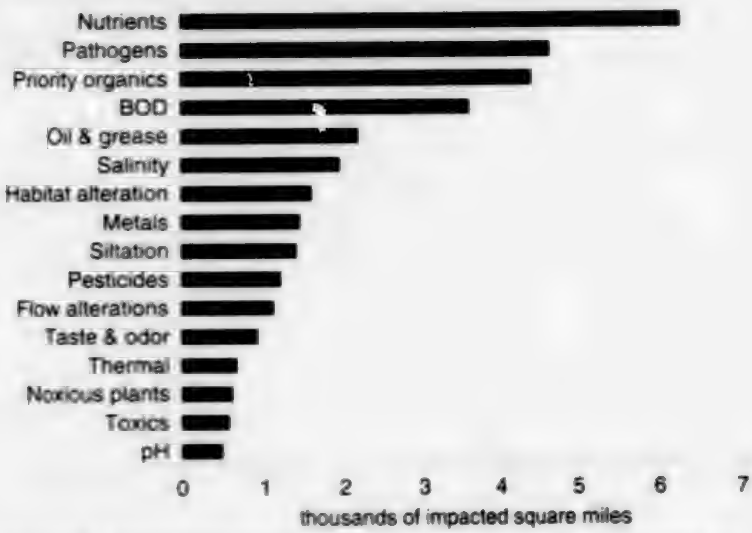
Roughly 83 percent of 1996 beach closings and advisories were based on detected bacteria levels exceeding beach water quality standards. An estimated 13 percent were in response to a known pollution event and 4 percent were precautionary closures resulting from rain that carried pollution to swimming waters. (Pollution events are often triggered by heavy rains that accompany hurricanes

Box Figure 6.4 Overall Use Support in U.S. Estuaries, 1996



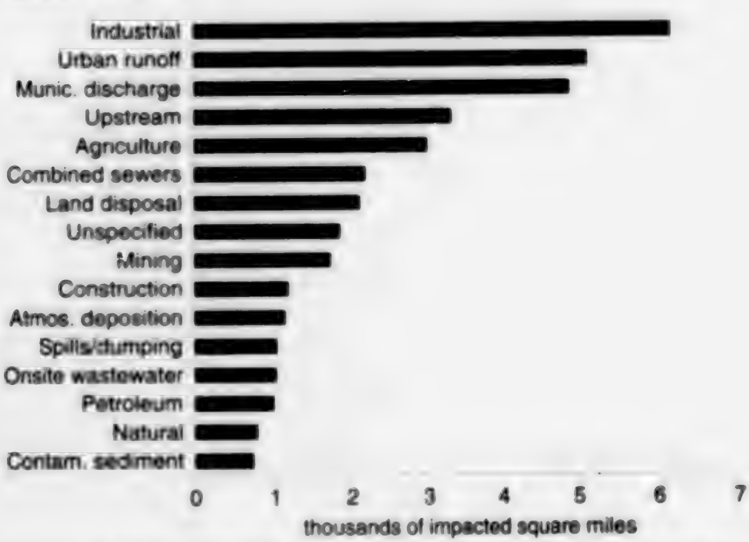
Source: See Part III, Table 6.4.
Note: Based on an assessment of 23,821 square miles or 60% of U.S. estuarine waterbody area.

Box Figure 6.5 Leading Causes of Impairment in U.S. Estuaries, 1996



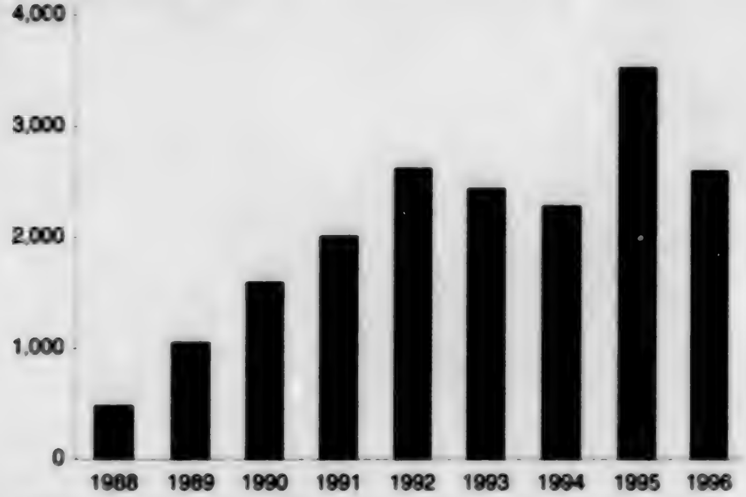
Source: U.S. Environmental Protection Agency, Office of Water, *National Water Quality Inventory: 1996 Report to Congress*, Table C4 (EPA, OW, Washington, DC, 1998)

Box Figure 6.6 Leading Sources of Pollution in U.S. Estuaries, 1996



Source: U.S. Environmental Protection Agency, Office of Water, *National Water Quality Inventory: 1996 Report to Congress*, Table C5 (EPA, OW, Washington, DC, 1998)

Figure 6.9 Number of U.S. Coastal Beach Advisories and Closings, 1988-1996



Source: Natural Resources Defense Council, *Testing the Waters 1997: How Does Your Vacation Beach Rate?* (NRDC, New York, NY, 1997).

Note: NRDC counts every day of an advisory/closure as one "beach closing." Does not include permanent or extended advisories/closures. Because of inconsistencies in monitoring and closing practices among states and over time, it is difficult to make comparisons between states or to assess trends.

and other storms, causing contaminated runoff.)

The number of beach closings in 1996 (Figures 6.9 and 6.10) was actually down from 1995, because of reduced hurricane activity in Florida and fewer heavy storms in California. The 1996 level of closings was comparable to the 1992-94 period. The major pollution sources in 1996 were polluted runoff from non-urban areas, sewer spills and overflows, urban stormwater runoff, and combined sewer overflows.

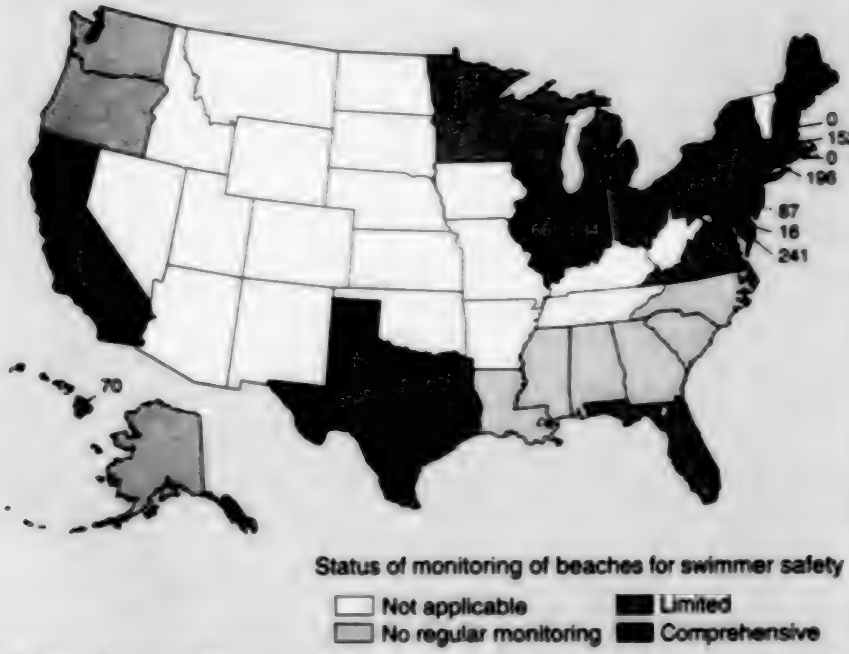
Nonindigenous Invasive Species

The introduction of nonindigenous aquatic species affects almost all of our nation's coastal, estuarine, and inland waters. These nonindigenous species have had severe local ecological and economic impacts in many areas. For example, according to the Great Lakes Sea Grant Network, facilities in the Great Lakes spent $120 million over six years (1989-94) for monitoring and control of the zebra mussel.

Though predation and competition, introduced species have contributed to the regional eradication of some native species and dramatic reductions in others. The continuous arrival of exotic species may make an estuary's ecosystem fundamentally unmanageable by continually changing the flora and fauna.

For example, there is documented evidence that 212 exotic species are established in the San Francisco Estuary.

Figure 6.10 U.S. Coastal Beach Advisories and Closings by State, 1996



Source: Natural Resources Defense Council, *Testing the Waters 1997: How Does Your Vacation Beach Rate?* (NRDC, New York, NY, 1997).

Notes: Numbers refer to the number of coastal beach advisories and closings. NRDC counts every day of an advisory/closure as one "beach closing."

Another 40 exotic species were discovered too recently to know if they are established, while an additional 123 established species are considered potentially exotic. Aside from numbers, these species are dominant in many of the Estuary's habitats. Overall, the average rate of invasion since 1850 has been one new exotic species established every 36 weeks, but the rate has increased to at least one new species every 24 weeks since 1970.

The establishment and spread of nonindigenous species has led to increasing restrictions on water diversions, levee maintenance, and other activities in and near the San Francisco Estuary. Introduced organisms contribute to the fouling of hulls on boats and ships, which can reduce vessels' speed and increase fuel consumption by 15 to 50 percent. The state of California has recently been spending about $400,000 per year to control exotic plants in the San Francisco Estuary and Delta, and over $1 million to keep exotic fish from reaching the Delta. All of these activities (anti-hull fouling, exotic plant and exotic fish controls) require releasing substantial quantities of chemicals into the environment.

Under the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, Congress established an Interagency Aquatic Nuisance Task Force to develop a coordinated federal program to prevent and control nonindigenous nuisance species. The Task Force was expanded to include state and regional representatives. The National Invasive Species Act of 1996 authorized further efforts to control and mitigate the impact of nonindigenous species. Control and mitigation approaches under development include national guidelines for ship ballast water management, development of state control plans, and public education and outreach.

Harmful Algal Blooms

Harmful algal blooms (HABs) have increased in frequency and severity in U.S. coastal areas over the past several decades. The most recent and visible examples are outbreaks of fish lesions and fish kills in estuaries of several Middle Atlantic and South Atlantic states and recent red tides and mass fish kills off the Texas coast.

The events on the East Coast are attributable to several toxic dinoflagellates, including *Pfiesteria piscicida*. Although this organism is similar to the toxic dinoflagellates that cause red tides, *Pfiesteria* in its non-toxic form is a single-celled predator that exists harmlessly in river sediment as either cysts or amoebae. In slow-moving, warm, brackish, nutrient-rich water, fish excretions are thought to trigger a transformation of the non-toxic *Pfiesteria* cysts into toxic dinoflagellate cells with whip-like tails. The dinoflagellates produce several toxins, which create lesions on fish in confined settings and also affect the immune system, liver, kidneys, and nervous system of trapped fish populations. Lab tests have shown that a *Pfiesteria* attack can kill healthy fish in less than 10 minutes.

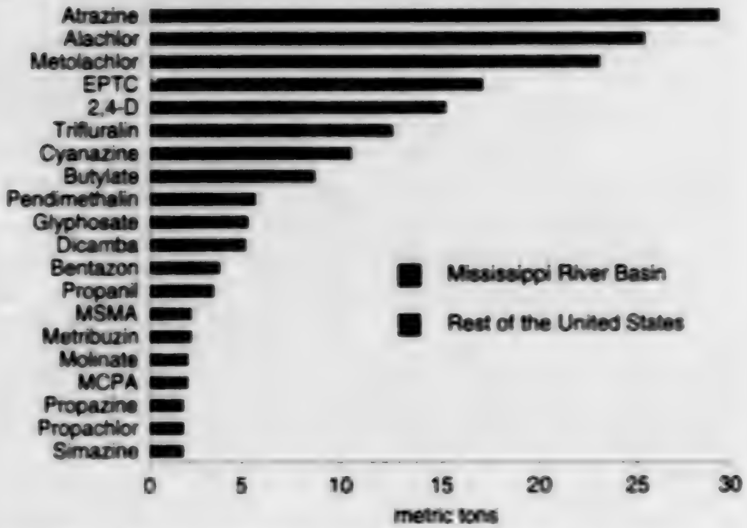
Pfiesteria were first observed in North Carolina, but have since been found as far north as the Indian River in Delaware and as far west as Mobile Bay. It has been shown that the *Pfiesteria* neurotoxin affects lab workers, fishers, swimmers, and other recreational users of nearshore marine and riverine waters during toxic episodes. Exposure may result in short-term memory loss, dizziness, muscular aches, vomiting, abdominal pain, and respiratory ailments.

An August 1997 *Pfiesteria* fish kill in the Pocomoke River in Maryland apparently caused serious health problems in 13 individuals. Ten of these people showed confusion and minor memory problems. Four of seven people who underwent a sophisticated brain scan test showed a particular abnormality of the brain, apparently caused by exposure to *Pfiesteria*.

The accumulation of dying fish and concerns for public health led Maryland Gov. Parris N. Glendening to close an eight-mile section of the Pocomoke in August, marking the first time that a state government has declared that the organism presented a risk to people in a natural environment. Subsequently, two other Eastern Shore rivers were closed.

Since 1993, federal agencies, including NOAA, EPA, DOI, and the National

Figure 6.11 Estimated Annual Herbicide Use in the Mississippi River Basin and Rest of the United States, 1987-1989



Source: Meade, R.H. (ed.), *Contaminants in the Mississippi River, 1987-92*, U.S. Geological Survey Circular 1133 (USGS, Reston, VA, 1995).

Science Foundation, have had in place a national plan of research, modeling, and management for HABs and their impacts. ECOHAB (*Ecology and Oceanography of Harmful Algal Blooms*), an interagency program established in 1996, is designed to provide specific information on the linkages between environmental conditions favoring optimal growth and toxicity of several noxious species, which is critical to the development of predictive models to forecast bloom events.

ECOHAB is supporting nine research projects on harmful algal blooms, including *Gymnodinium breve*, *Alexandrium tamarense*, *Aureococcus anophagefferens*, and *Pseudo-nitzschia*. Additional projects are currently being selected and will expand to other species, including *Pfiesteria*.

Pollutant Transport

Since 1975, the U.S. Geological Survey and others have studied pesticide concentrations in streams draining agricultural basins in a 10-state region of the Midwest. The studies reveal that rivers can transport environmental pollutants hundreds and even thousands of miles downriver to the river's terminus and into an estuary.

For example, take the case of atrazine, one of the most commonly used herbicides for weed control in corn and sorghum production (Figure 6.11). Most streams contain water with high concen-

trations of atrazine for several weeks to several months following the application of pesticides to farmlands. Concentrations generally are largest and may briefly exceed health-based limits for drinking water (3 micrograms per liter) during runoff from the first storms after application. Concentrations decrease during later runoff events.

The widespread occurrence of atrazine in these medium-sized streams raised questions about the magnitude and transport of atrazine down the large rivers that drain the basin. In the spring of 1991, USGS sampled for atrazine and four other herbicides in the Mississippi River and several of its major tributaries. Atrazine exceeded the maximum contaminant level in 27 percent of the samples, including a sample at Baton Rouge that was hundreds of miles from the major source of atrazine in the Midwest. Load calculations indicated that about 37 percent of the atrazine discharged from the Mississippi River into the Gulf of Mexico entered the river from streams draining Iowa and Illinois.

The second largest source was the Missouri River basin, which contributed about 25 percent of the atrazine entering the Gulf (Table 6.1). Although the annual mass transport appears to be large for several pesticides, it represents only a small fraction, generally less than 3 percent, of the pesticide mass applied annually to cropland in the basin. Temporal variations in the concentrations of herbicides in the Mississippi River reflect two factors: (1) the application of the herbicides on croplands, and (2) the rainfall and runoff events that follow the applications. It was anticipated that higher streamflows during the great flood of 1993 would dilute concentrations of herbicides that are usually flushed into streams in the spring and summer. Instead, concentrations and daily loads were higher than those measured in the previous years (Figure 6.12), probably because the intense and sustained rainfall fell shortly after planting in many areas and near the time when the most concentrated amounts of herbicides were on the soil. The total load of atrazine discharged to the Gulf of Mexico from April through August 1993 (1.2 million pounds, or 2.3 percent of the total

Pollution threatens valuable crops such as Gulf shrimp.

Photo Credit
S.C. Delaney/EPA

Table 6.1 Estimated Loads of Selected Pesticides Transported by the Mississippi River and Major Tributaries, April 1991 through March 1992

Pesticide	Illinois River	Missouri River	Ohio River	Mississippi River Above Missouri River[1]	Mississippi River at Thebes, IL[2]	Mississippi River Below Ohio River[3]	Mississippi River at Baton Rouge, LA[4]
				thousand kilograms			
Alachlor	8.79	7.87	4.97	35.00	42.90	47.90	33.70
Atrazine[5]	40.00	76.80	70.40	144.00	221.00	291.00	365.70
Butylate	0.21	0.31	1.17	0.96	1.27	2.44	na
Carbofuran	0.36	1.19	0.30	1.81	3.00	3.30	na
Cyanazine	19.60	31.30	13.40	81.70	113.00	126.00	127.00
EPTC	0.52	0.11	0.13	0.83	0.93	1.06	na
Metolachlor	18.90	24.70	20.20	62.50	87.20	107.00	123.00
Metribuzin	0.60	1.42	0.55	3.09	4.51	5.06	6.81
Prometon	0.51	0.43	0.82	0.77	1.20	2.02	na
Simazine	0.86	1.09	9.37	3.25	4.34	13.70	12.50

Source: Goolsby, D.A. and W.E. Pereiri, "Pesticides in the Mississippi River," in R.H. Meade (ed.), *Contaminants in the Mississippi River, 1987-92*, U.S. Geological Survey Circular 1133 (USGS, Reston, VA, 1995).

Notes: [1]Calculated from load in Mississippi River at Thebes, IL, minus load from Missouri River. [2]Above confluence with Ohio River. [3]Below confluence with Ohio River, calculated from load in Mississippi River at Thebes, IL, plus load in Ohio River. [4]Approximate transport from Mississippi River Basin to Gulf of Mexico, includes diversion into Atchafalaya River but not the contributions from the Red River. [5]Atrazine plus metabolites. na = no load estimate available.

amount applied annually to cropland in the Mississippi basin) was about 80 percent larger than the load for the same period in 1991 and 235 percent larger than in 1992.

The story is similar for the discharge of nitrogen from interior basins to the Gulf of Mexico. Excess nitrogen from a diversity of sources—fertilizers, animal manure, decaying plants, municipal and domestic wastes, and atmospheric deposition—enters the Gulf from the entire Mississippi watershed (Figure 6.13). These nutrients nourish an algae bloom. When the algae die, they drop to the bottom and decompose, a process that takes so much oxygen from the water that other marine organisms—fish, shellfish, and other bottom-dwellers—either die or move out of the zone. This deadly "hypoxic" zone, which forms each spring and summer off the coast of Louisiana, now covers an area of about 7,000 square miles (Figure 6.14), roughly the size of New Jersey. Smaller dead zones also have appeared in recent years in Chesapeake Bay, Florida Bay, and North Carolina's Pamlico and Albemarle sounds.

Much of the nitrate-nitrogen concentration entering the Gulf comes from sources a thousand miles upstream. Studies indicate that the principal regions

contributing to the nitrogen load are the Upper Mississippi (31 percent), Lower Mississippi (23 percent), Ohio (22 percent), and Missouri (11 percent) river watersheds.

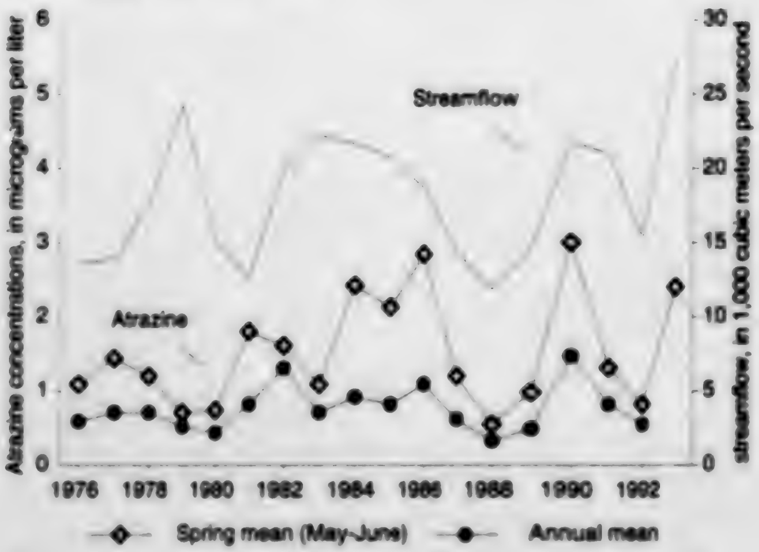
The victims of this pollution are Gulf fishermen, who are forced to avoid the dead zone area, fishing either closer to shore or traveling long distances into the Gulf. The economic impact of the dead zone problem is not precisely known, but marine fisheries contribute more than $1 billion a year to Louisiana's economy.

In mid-1997, the federal government created a federal task force on the dead zone problem and launched an 18-month multidisciplinary assessment that will explore the causes of the problem and possible solutions.

URBAN POLLUTION: THE CASE OF BOSTON HARBOR

The effort to control pollution in Boston Harbor provides an example of many of the problems facing the nation's older port cities: a watershed with many political jurisdictions and sources of pollution, old or out-of-date wastewater treatment equipment, and limited financial resources. As a result of these and other

Figure 6.12 Atrazine Concentrations in the Mississippi River at Vicksburg, MS, 1976-1993



Sources: Goolsby, D.A. et al., *Occurrence and Transport of Agricultural Chemicals in the Mississippi River Basin, July Through August 1993*, U.S. Geological Survey Circular 1120-C (USGS, Reston, VA, 1993). Meade, R.H. (ed.), *Contaminants in the Mississippi River, 1987-92*, U.S. Geological Survey Circular 1133 (USGS, Reston, VA, 1995).

Notes: Data for 1993 are for July through August at Baton Rouge, LA. Earlier data on atrazine concentrations from this station are approximately equivalent to those from the Vicksburg station.

Figure 6.13 Nitrogen Flux to the Gulf of Mexico from the Interior Basins

Source: USDA/NRCS based on data from R.B. Alexander, R.A. Smith, and G.E. Schwartz (USGS) and N.N. Rabalais, R.E. Turner and W.J. Wiseman, Jr. (Louisiana Universities Marine Consortium) #RWH 1606 1996

factors, Boston Harbor in the mid-1980s was a severely degraded ecosystem.

The Boston Harbor project resulted in part from a 1985 court ruling that wastewater discharges into Boston Harbor from the Deer Island wastewater treatment plant violated the Clean Water Act. In response to this ruling and other pressures, the Massachusetts Water Resources Authority (MWRA) led a comprehensive effort to reduce pollution and restore the harbor ecosystem. The $3.7 billion project includes construction of primary and secondary wastewater treatment facilities, odor control facilities, a disinfection facility, new sludge digesters, an effluent outfall tunnel, a tunnel connecting Nut Island and Deer Island (site of existing treatment facilities), and new and rehabilitated pumping stations.

Figure 6.14 Estimated Size of the Dead Zone in the Gulf of Mexico, 1985-1997

Source: Rabalais, N.N. et al., Louisiana Universities Marine Consortium, Hypoxia Monitoring Data.

Mobilizing the Watershed

The MWRA recognized that their effort would have to include the entire watershed. MWRA's water and sewer systems serve more than 2 million state residents as well as industries and businesses in 61 cities and towns. The system imports hundreds of millions of gallons of water per day to the Boston Harbor watersheds from several sources in western and central Massachusetts that would otherwise naturally drain to Long Island Sound via the Connecticut River, or to the Gulf of Maine via the Merrimack River. Much of the imported water eventually becomes household and industrial wastewater that is transported through a network of local sewers and interceptors (large regional sewers) to the Deer Island and Nut Island plants. The wastewater also includes runoff, rainwater, and snowmelt that is carried from parts of Boston, Cambridge, Somerville, and Chelsea. Together these flows make up the 370 million gallons of sewage collected for treatment on an average day.

Approaching the cleanup problem on a watershed basis meant understanding the various sources of pollution in the watershed and the differences among watersheds. For example:

- As the Charles River reaches the urban communities along its route to the harbor, high bacteria counts impair its use. Raw sewage from combined sewer overflows and contaminated storm drains adversely affect the Charles River basin, the Back Bay fens, and the Muddy River.
- Past industrial pollution in the upstream portion of the Neponset River watershed has resulted in high levels of toxic contamination, while sewage discharge from downstream combined sewer overflows remains a problem for both the river and the beaches along Dorchester Bay.
- In the Mystic River watershed, pollution from oil port operations in the Chelsea and Island End rivers adversely affects the health of marine animals and the biodiversity of the bottom-dwelling community.

The CSO Problem. Within the watershed, there were some 81 combined sewer overflows (CSOs) carrying both sewage and stormwater runoff. These antiquated systems were designed so that, if stormwater overflow is more than the system can handle, a mixture of stormwater and raw sewage overflows into the receiving body of water rather than backing up into the streets.

In 1990, MWRA developed a CSO Facilities Plan that would have built miles of deep rock tunnels to store combined sewage that would otherwise overflow during storms. In dry weather, the stored combined sewage would be pumped to the treatment plant. After gathering more sewage flow data, however, MWRA officials learned that both the volume and the environmental effects of combined sewage had been overestimated and that the costly tunnel system might not be necessary.

A new CSO plan was developed that looked at the relative impacts of various pollution sources. The primary problem

was the risk to public health from sewage-borne pathogens (disease-causing bacteria and viruses), which make swimming and shellfishing unsafe, so the plan put special emphasis on eliminating CSOs near beaches and clam flats. By separating sewers or by relocating the CSOs to other, less sensitive areas, beaches in East Boston and South Boston and shellfish beds in the Neponset River estuary could be better protected.

In areas where CSOs appear to be a much less significant source of pollution than other sources, a more modest level of CSO control will be applied. For example, even with CSO disinfection in the Charles River, swimming in the Charles River basin will remain a health risk unless other sources of pathogens are controlled as well.

Larger, more complex projects will be implemented and ultimately owned and operated by MWRA, while local communities will be responsible for projects involving improvements to their pipes and to their CSO outfalls. More flow will be treated by CSO treatment facilities, and some overflows will be prevented by enlarging sewers or building small storage facilities. Larger sewer separation projects will extend over a number of years.

After the CSO plan is fully implemented, there will still be some occasional overflows in some areas (less than four times per year on average), but the volume discharged will be greatly reduced. Wherever the potential for large CSO discharge remains, including the Charles River basin, Fort Point Channel, and the Reserved Channel, the discharge will be disinfected.

Improvements to the system already are evident. Since CSO discharge volume depends to a large extent on rainfall in any given year, the fact that CSO discharge volume declined in 1994 compared to 1990 – even though there was more precipitation in 1994 – is a promising sign of progress. MWRA officials attribute the progress to completion of a number of small-scale sewer system improvement projects, improved efforts to clean sewers and maintain regulators and tide gates, and recent operational improvements at MWRA's "headworks" facilities, which remove rags, grit, and large objects from sewage before it enters the treatment plants.

MWRA also has started several other projects within the watershed:

- Interceptor construction and replacement projects will increase the capacity of old interceptors and prevent untreated sewage from entering the rivers and groundwater.
- Pollution prevention programs are helping industries, municipalities, businesses, and residential neighborhoods decrease the amounts of toxic metals and other contaminants that enter the region's sewers.
- An infiltration/inflow assistance program provides over $20 million to MWRA communities for projects to reduce stormwater and groundwater flow into the sewage collection and treatment system. Under the leadership of the Massachusetts State Water Resources Authority and others, a comprehensive effort is underway to

reduce pollution and restore the harbor ecosystem.

Modernizing Treatment

One of the biggest challenges facing the authority was the condition of the Deer Island and Nut Island sewage treatment plants, two old primary treatment plants that could not meet federal and state standards. These plants were given interim standards until the new, federally mandated secondary treatment plant at Deer Island was completed.

During the construction period, the old plants at Deer Island and Nut Island had to continue operating. At Deer Island, this meant keeping the old plant running while building the new one around it. At Nut Island, the old plant had to be kept running until completion of the new Nut Island-to-Deer Island tunnel.

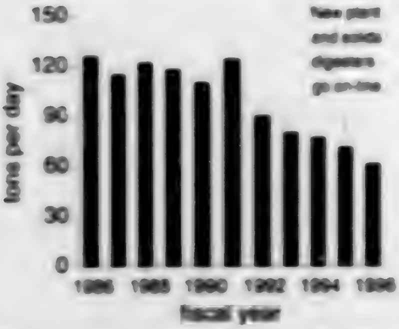
During this period, MWRA installed a computerized tracking system in the early 1990s and began to substantially step up its follow-up and enforcement actions against industries that did not meet their discharge permit requirements.

On January 20, 1995, MWRA started up the new Deer Island primary treatment plant. The new facility will treat sewage from both the North and South systems, and the Nut Island plant will be decommissioned. Sewage flows from the South System will be sent to Deer Island through a new inter-island tunnel. The new Deer Island facility will ultimately provide both primary and secondary treatment for both systems.

Through all six stages of the treatment process, the new plant provides substantial improvements:

- Ten new pumps have been installed to improve movement of wastewater from the 43 sewer communities. The old pumps frequently broke down, causing sewage to back up and overflow into the harbor.
- New vortex grit chambers — the largest of their kind in the United States — will improve removal of heavy particles like sand and coffee grounds.
- Larger settling tanks in the new plant have dramatically increased the plant's ability to remove solids and scum from wastewater. In FY 1996, Deer Island's solids discharge into Boston Harbor dropped to 61 tons per day, down from 71 tons per day in the previous year and less than half the 1986 level.
- Digesters break down solids collected during the treatment process, destroying pathogens and producing methane gas to help heat and power the plant. The plant's new digesters allow better mixing, improve production of methane, and minimize maintenance problems that troubled the old plant.
- Effective disinfection depends upon how long harmful bacteria in wastewater are exposed to sodium hypochlorite before discharge. The new plant has improved the disinfection process by doubling the contact time from 15 minutes to 30 minutes, providing more effective bacteria kill and using less sodium hypochlorite in the process.
- In the old plant, gases and odors escaped freely into the atmosphere. In

Figure 6.15 Solids Input to Boston Harbor from Deer Island Treatment Plant, 1986-1996



Source: Massachusetts Water Resources Authority, *The State of Boston Harbor 1996: The New Treatment Plant Makes Its Mark* (MWRA, Boston, MA, 1996).
Note: The ending of sludge discharges in December 1991 also contributed to observed improvements.

the new plant, the primary settling tanks are covered so that gases are trapped until they are treated with chemicals that remove the odors.

When the secondary treatment facilities became operational at the end of 1996, still more solids were removed during the wastewater treatment process (Figure 6.15).

A new effluent outfall tunnel, to be completed in 1998, will be the largest such tunnel in the world. This 24-foot-diameter tunnel, lying 300 feet below the ocean floor, will carry treated effluent 9.5 miles into Massachusetts Bay, where 55 diffusers – resembling giant sprinkler heads – will disperse the discharge into the deep waters of Massachusetts Bay. Many federal agencies, including NOAA and the National Marine Fisheries Service, worked with state, local, and other federal agencies on the development of the outfall and on ways to minimize any adverse effects on the marine environment.

MWRA officials are confident that the new outfall will significantly lessen the impact on the Bay ecosystem, since the secondary effluent to be discharged into the Bay will be much cleaner than the primary effluent and sludge that was discharged into the harbor until 1991. Furthermore, the discharge site in the Bay was selected because it provides for much greater dilution than would be possible in the shallow waters of Broad Sound or Boston Harbor.

A computer model predicts that the effluent will have only limited impacts near the outfall and virtually no effect on Cape Cod Bay. Chlorophyll-a, a measure of algal blooms, will increase only in the immediate outfall area, and will decline significantly in Boston Harbor. The deposition of organic matter on the sediments that can reduce bottom dissolved oxygen (DO) will be dramatically reduced in both the harbor and the bay. Bottom DO will improve because primary effluent, with a higher oxygen demand than secondary effluent, will no longer be flowing from the harbor into the bay.

MWRA's NPDES permit will incorporate stringent limits and testing requirements for Deer Island effluent discharges. In addition, MWRA plans to provide an intensive monitoring program for the outfall.

The large investment in improving Boston Harbor's water quality is already showing results. Beach postings have declined dramatically since the mid-1980s, bottom-dwelling animal commu-

nities have increased in abundance and diversity; flounder caught in Boston Harbor are now safe for human consumption, and PCB and mercury levels in flounder fillets are now well below FDA limits.

Despite this progress, there is a concern that the outfall will negatively impact the resources of Stellwagen Basin and Stellwagen Bank, a National Marine Sanctuary, which is an important feeding ground for marine mammals such as the endangered humpback and right whales. The Outfall Monitoring Task Force needs to continue to monitor the health of the ecological community by assessing species abundance and diversity in Stellwagen Basin, in Cape Cod Bay, and near the outfall.

PROTECTING SOUTH FLORIDA'S ENVIRONMENT

In the past 150 years, large water control projects have transformed the Everglades ecosystem from a vast subtropical wetland into a multiple-use, human-dominated system with some natural remnants. Each phase of this transformation has been marked by a series of crises—both cause and effect of the changes. (See Chapter One for a brief history of the South Florida ecosystem.)

The effort to restore the South Florida ecosystem began in 1983, when the state announced a "Save Our Everglades" campaign. The campaign goal was to restore key hydrologic functions of the original natural system.

After much study and evaluation, the state in 1990 adopted a plan developed by the South Florida Water Management District that would restore 40 miles of the original Kissimmee River ecosystem, 43 miles of river, and 26,500 acres of wetlands. In 1992, Congress authorized the Corps of Engineers to enter into a 50/50 cost-share arrangement with the state to begin work on the $400-million project. The plan also led to federal legislation to expand Everglades National Park into Northeast Shark Slough. Land acquisition in the park expansion area is proceeding, as well as construction modifications to re-water the area.

To help control runoff from farming into Lake Okeechobee, the state focused on reducing dairy farming on lands draining into the lake and on instituting best management practices on remaining farms. Efforts to protect the Water Conservation Areas have focused on regulations and treatment of agricultural discharges and on land acquisition in the conservation areas. Extensive federal, state, and local land acquisition has also been the focus at Big Cypress National Preserve and in protecting the Florida panther; about 150,000 acres of panther habitat have been acquired, including Florida Panther National Wildlife Refuge.

Notwithstanding these efforts, by 1988 the evidence was clear that agricultural pollution, especially phosphorus, was damaging Everglades National Park and the Loxahatchee National Wildlife Refuge. The federal government filed suit against the state of Florida for failing to enforce its own water quality laws.

In 1991, the state settled the litigation and agreed on a plan to remove 80 per-

cent of the phosphorus flowing into the Everglades from the Everglades Agricultural Area, by improving agricultural practices and constructing filtration marshes called Stormwater Treatment Areas. The settlement agreement also required expanded research and monitoring, compliance by 2002 with all water quality standards in water delivered to the park and refuge, adoption of strict phosphorus limits for water in the park and refuge, and a new water delivery schedule aimed at maintaining the flora and fauna of the park and refuge.

The settlement was adopted by the federal court as a consent decree in 1992, but it was subsequently tied up by 36 federal and state lawsuits. In July 1993, after nine months of negotiations, the parties agreed to a Statement of Principles. The agreement provides for a $465 million system of Stormwater Treatment Areas (about 35,000 acres of filtration marshes to cleanse great volumes of water and improve water quantity, distribution, and timing benefits for the Everglades) and on-farm best management practices.

Key features of the plan were adopted by the Florida legislature in April 1994. The state is to construct five Stormwater Treatment Areas by 2003 and the Corps of Engineers must build one by 2002. The state is required to pay roughly 42 percent of the cost of the plan, while farmers will pay 50 percent and the federal government will pay 8 percent. Stormwater Treatment Areas are to be permitted and regulated by the Florida Department of Environmental Protection, the Corps, and EPA. Agricultural discharge is to be regulated by the South Florida Water Management District through permits that will impose best management practices to reduce phosphorus loads. In addition, the state is required to conduct an extensive research and monitoring program for the Everglades.

To improve interagency coordination, the Department of the Interior in June 1993 convened a South Florida Ecosystem Restoration Task Force, composed of federal agencies (the Corps of Engineers, EPA, NOAA, the Department of Justice, USDA's Natural Resources Conservation Service, and Interior's National Park Service, Fish and Wildlife Service, U.S. Geological Survey, and Bureau of Indian Affairs) who are responsible for restoring and maintaining the integrity of the South Florida ecosystem. In 1994, Governor Lawton Chiles also established a Commission for a Sustainable South Florida, which now includes 48 members from state, tribal, and local governments, business and public interest groups, along with five nonvoting members from the federal government. Like the federal group, the commission's primary mandate is to improve coordination among the many interests involved in the Everglades restoration effort.

According to a case study prepared for the Interagency Ecosystem Management Task Force, the effort to improve joint planning and coordination and to implement an ecosystem approach faces many constraints. For example, federal agencies have traditionally planned their budgets independently. Currently, most agencies are working together on projects, but the traditional budgeting process still often remains an impediment to allocating

funds to support the integrated priority needs of the ecosystem. A related barrier is that no federal agency has been assigned to coordinate the ecosystem approach for the region.

The case study also noted that there are a number of constraints to effective communication and the more flexible approach characterized by "adaptive management," in which activities are modified based on new information that emerges as the consequences of current projects become clear. The Administration has worked to remove many of these barriers. For example:

- The Federal Advisory Committee Act (FACA) places restrictions on the ability of federal agencies to solicit advice from nonfederal parties without having to go through a cumbersome chartering process. In the past, the South Florida Ecosystem Restoration Task Force operated under FACA and had no nonfederal members and no ongoing, systematic contact with nonfederal government parties. In 1997, the task force was re-established and reorganized (under provisions of the 1996 Water Resources Development Act exempting it from FACA) to include nonfederal members. The task force now includes representatives from the state, the South Florida Water Management District, local government, and the Miccosukee and Seminole Indian tribes.
- The laws and regulations governing initiation of Corps projects result in a lengthy, rigid, and complicated process that often makes projects susceptible to derailment or makes them difficult to modify after completion. The Corps has established new procedures to streamline the review process.
- The Endangered Species Act and other laws emphasize both the protection of ecosystems and of individual species. The current emphasis on the ecosystem approach and on multi-species recovery will be used to reconcile cases like that of the Cape Sable seaside sparrow and the snail kite in South Florida, where the law's emphasis on individual species also pertains.

On a variety of fronts, progress to restore the system is well underway:

- Stormwater Treatment Area 6 was completed in October 1997, which will allow natural processes to reduce nutrient runoff from the Everglades Agricultural Area.
- Modification of Canal 111 began in 1996, which will maintain flood protection and restore more natural flows into the Everglades.
- About 85 percent (80,000 acres) of the lands necessary to restore the Kissimmee River have been purchased, with the goal of restoring the river and 27,000 acres of wetlands by 2009, while maintaining flood protection.
- About 61,000 acres have been added to Everglades National Park, and an additional 48,000 acres will be acquired to help restore the natural flow of water to the Everglades.
- Nutrient runoff from the Everglades Agricultural Area was reduced significantly between 1995 and 1997.

- About 90,000 acres were cleared of introduced melaleuca plants as part of the expansion of the exotic species control program.

Cumulative Effects: From the Everglades to Florida Bay and the Keys

The decline in freshwater flow that afflicts the Everglades also seems to be having an impact on the marine ecosystem of Florida Bay, and problems in Florida Bay may in turn threaten the Florida Keys National Marine Sanctuary. The sanctuary includes the entire 220-mile length of the Florida Keys and some 2,800 square nautical miles of nearshore waters. The sanctuary has some spectacular marine environments, including seagrass meadows, mangrove islands, and extensive living coral reefs.

The development of the sanctuary has been widely praised as an exemplary effort to use the ecosystem approach and to include a wide array of interests in planning and decisionmaking.

A partnership of federal, state, and local agencies was created for planning and management, and representatives of local interests—citizens, scientists, environmentalists, and business leaders—are participating. A Citizens' Advisory Committee reviews major documents produced by government agencies, including NOAA's Comprehensive Management Plan and the Water Quality Protection Program developed by EPA and the state.

Florida Bay has experienced severe water quality and ecological problems in recent years. Since 1987, a massive seagrass die-off has denuded thousands of acres of sediments. The seagrass die-off and resulting sediment resuspension and nutrient release were a major cause of massive phytoplankton blooms that have affected the bay. In turn, sponge die-offs caused by phytoplankton blooms created further impacts on juvenile spiny lobsters, which reside by day under sponges for protection from predation. Recent wet weather cycles have reversed some of these trends in Florida Bay and provide hope that the restoration plan will be successful.

Water quality and natural resources in Florida Bay are tightly linked to those of the marine sanctuary. According to some coral experts, for example, Florida Bay water may be contributing to coral declines in the sanctuary.

Land-based sources in the Everglades and Florida Keys are contributing to the area's water quality problems. The Bay drains much of the adjacent Everglades, receiving freshwater flows from the agricultural areas, marshes, and canals. According to EPA estimates, domestic wastewater discharges from land-based sources account for about 70 percent of the wastewater/stormwater nutrient loadings in the sanctuary area. Domestic wastewater facilities in the Keys include about 30,000 regulated on-site sewage disposal systems, 10,000 unregulated cesspits, over 200 small package plants, and two municipal wastewater treatment plants in Key West and the Key Colony Beach.

The Water Quality Protection Program (WQPP) developed by EPA and the Florida Department of Environmental Protection was developed with the help of a wide array of institutions and interested citizens in the Keys ecosystem.

Using federal and state funds, EPA and the state have initiated a comprehensive water quality monitoring and research program to protect the sanctuary area—the State/Federal Management Plan for the Florida Keys National Marine Sanctuary, which was adopted in January 1996. The protection program recommends a long list of actions to reduce pollution from domestic wastewater and stormwater sources, including establishing and implementing inspection and enforcement programs to eliminate all cesspits and enforce existing standards for all on-site disposal systems and package plants.

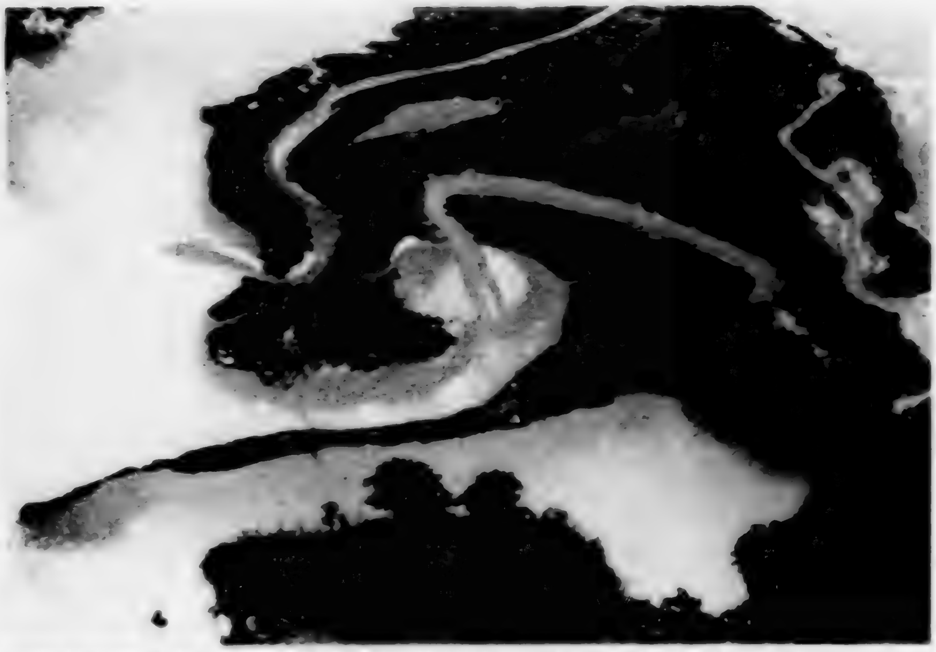
The program recommends restoration of the historical freshwater flow to Florida Bay and coordination by Everglades and South Florida officials to ensure that water quality management plans support water quality goals for the sanctuary.

Federal and state funds are also supporting an intensive research and modeling program in Florida Bay. This program is organized and coordinated under a federal-state Program Management Committee, which sets research priorities, reviews project results, and recommends activities to address information gaps. The objectives of the interagency program are to characterize existing environmental conditions in the Bay, monitor changes in the system, and apply this knowledge to predicting the potential implications of various Everglades restoration scenarios to Florida Bay and the Keys. The resulting models and information are very important to the Interagency Ecosystem Restoration Task Force because restoration decisions made for the Everglades could significantly affect Florida Bay and the Keys.

COASTAL WETLANDS

The Gulf of Mexico, South Atlantic coast, Great Lakes, ocean coastlines, and some rivers contain major concentrations of coastal wetlands, which are among the earth's richest and most productive habitats. Coastal wetlands, which form transitional areas between permanently flooded freshwater and marine aquatic environments and well-drained uplands, provide a variety of important ecological functions. They act as nurseries and temporary shelter to many species, including many endangered species and commercially important species such as flounder, menhaden, shrimp, oysters, and clams. Nearly all waterfowl, wading birds, and shorebirds migrating along the North American flyways find abundant food, rest stops, and nesting areas in the marshes and mudflats of coastal estuaries.

Coastal wetlands are critical to many economically important fisheries. In the Southeast, 94 percent of the commercial catch and over 50 percent of the recreational harvest are fish and shellfish that depend on the estuary-coastal wetlands system. In 1996, the dockside value of fish landed in the United States was $3.6 billion. The industry employs hundreds



Intense demand for development puts pressure on coastal wetlands like this one on Chesapeake Bay.

Photo Credit
S.C. Delaney/EPA

of thousands of people, and consumers spend over $41 billion annually on fisheries products. An estimated 71 percent of this value is derived from fish species that during their life cycles depend directly or indirectly on coastal wetlands.

Both human activities and natural events threaten coastal wetlands. People dredge and fill areas, extract resources, introduce non-native species, contaminate stormwater runoff, and construct features that reduce tidal flows or freshwater inflows. Oil and gas activities withdraw resources, resulting in subsidence. Nature alters the coast through storms, saltwater intrusion caused by sea level change and land subsidence, and the normal succession of coastal wetlands into coastal uplands.

Louisiana's Coastal Wetlands

Almost 40 percent of all coastal marshes in the United States are in Louisiana, an area of about 2.5 million acres of fresh, intermediate, brackish, and saline marshes, and about 637,000 acres of forested wetlands. These wetlands are of immense economic value, supporting a commercial harvest of fish and shellfish with a market value of almost $1 billion annually, an estimated $250 million per year in income from ecotourism, and another $50 million from recreation.

The loss of the region's coastal wetlands reflects long-term impacts of development since the 19th Century. The construction of flood protection levees and navigation improvements along the Mississippi River ensured that most sediment bypassed the areas where it would naturally build and nourish wetlands during flood and nonflood period. Active channels such as Bayou Lafourche were blocked at the confluence with the Mississippi, cutting off vast wetland areas of the Delta from their life-sustaining supply of freshwater and transported sediment. Jetties and deep navigation channels at the mouths of tributaries direct sediments away from the Delta and into deeper waters of the Gulf of Mexico. Sediment deposits no longer compensate for the effects of natural coastal subsidence.

Coastal wetlands are increasingly submerged, killing many wetland plants and causing changes in vegetation. Channels dredged for navigation or oil and gas exploration also are causing intrusions of saltwater into normally fresh or brackish wetlands. In other areas, urbanization, highways, and spoil banks from channel dredging disrupt natural drainage and sediment distribution.

The net result has been the functional and physical loss of hundreds of thousands of acres of wetlands as natural vegetation dies and sediment erodes away. Estimates in the 1960s placed annual losses at 39-42 square miles annually. Current losses are now estimated at about 25-35 square miles per year. Only a small fraction of annual losses stems from new development. Permits for new development were taking about 3,000 acres annually around 1980, but are now taking less than 200 acres. Most current losses are the legacy of earlier modifications that disrupted the natural processes.

The state has been working for over two decades to prevent further losses on barrier islands and wetlands. In 1989, Louisiana voters approved, by a 3-to-1 margin, a constitutional amendment establishing a trust fund to generate about $25 million per year for restoration activities.

In 1990, Congress passed and the President signed the Coastal Wetland Planning, Protection, and Restoration Act (CWPPRA). The act established a six-member Louisiana Coastal Wetlands Conservation and Restoration Task Force, with representatives from the state and five federal agencies: Interior, Commerce, Agriculture, EPA, and the Corps of Engineers. (Several other similar restoration programs are underway in other states.)

The task force has provided an effective forum for discussions among federal and state agencies on developing a restoration plan. In particular, the act led to integration of the traditionally independent planning and execution of budgets by federal agencies with an interest in the issue.

With the help of several technical committees and groups, the task force succeeded in developing a Louisiana Coastal Wetlands Restoration Plan. A work group prepared lists of priority projects and developed plans for monitoring project effectiveness. The Corps estimates that about 211,000 acres of wetlands would be restored under the plan.

Funds for implementing the plan have approached $40 million annually, with costs shared by state (25 percent) and federal (75 percent) governments. One of the strengths of the plan is that the budget includes funds for 20 years of monitoring. This should enable the state and the task force to make necessary adjustments to projects and planning.

Some 80 percent of the coast is privately owned, and the state estimates that real-estate-related activities take about one third of the total effort required prior to implementation of a project. State and federal agencies are actively working with private landowners to resolve conflicts. The Louisiana Department of Natural Resources has created a real estate section to help speed up the process. The department is also negotiating a settlement with the Louisiana Land and Exploration Company concerning mineral rights when new land is created during restoration of the Isles Dernieres chain of barrier islands. Constitutional amendments are before the state legislature that would resolve important land rights and oyster lease issues.

Highways and Wetlands

Many post-war highway and road projects, as well as earlier rail lines, were built in coastal wetland environments that at the time were considered of little value. In many cases, these projects substantially altered tidal flows and degraded coastal wetlands.

The rehabilitation of these highways presents a new opportunity to correct some of the environmental mistakes of the past. For example, designing culverts that more closely approximate tidal flows and constructing larger channels in and around transportation facilities could significantly help restore the productivity of damaged salt marshes.

Coastal America, a federal interagency partnership on coastal issues involving about a dozen federal agencies, recently studied transportation-related wetland restoration opportunities in Connecticut and Cape Cod. The Connecticut study focused on sites where the dominant species was the common reed (*Phragmites australis*), a highly invasive plant that dominates disturbed and tidally restricted areas.

The studies found that high marshes dominated by *Phragmites australis* are well-suited for restoration by increased saline flushing. Higher salinities can help more desirable and productive salt marsh vegetation drive out *Phragmites*. As the Phragmites plants disappear with an increase in salinity, native salt marsh plants will often recolonize spontaneously, thus precluding the need for expensive and difficult planting and transplanting projects.

The study issued a few cautionary notes about such restoration projects. For example, increased salinity conditions could subject shellfish beds to greater predation and/or a proliferation of protozoan diseases.

Using the results of the Coastal America study, the Connecticut Department of Environmental Protection applied for federal funding under the Intermodal Surface Transportation Act (ISTEA) for the restoration of Sybil Creek and Mill

Meadows salt marshes. This project represents the first commitment of ISTEA funding for salt marsh restoration in the nation.

Coastal America also has supported a variety of other wetland restoration projects around the country. For example:

- At the Roosevelt Roads Naval Station along the eastern coast of Puerto Rico, a proposed project would restore tidal flushing to about 1,000 acres of mangrove forest. In the late 1940s, construction of a two-mile road blocked four natural channels and stopped tidal exchange along the eastern boundary of the forest. The project includes demolition of existing causeways, construction of a new causeway with bridges to allow greater tidal flow and saltwater exchange, and the clearing of damaged and fallen mangroves restricting existing culverts. The Puerto Rico Trust will be involved in the planting of new mangroves in areas that were severely damaged.
- In the Sacramento Delta in San Francisco Bay, a proposed project would restore about 1,300 acres of wetlands around Prospect Island. The project will breach a levee and restore full tidal action to the site. Partners in this $5 million project include the Corps of Engineers, the Bureau of Reclamation, the Fish and Wildlife Service, and the CalFed Bay-Delta Program. Construction is scheduled to begin in 1998.

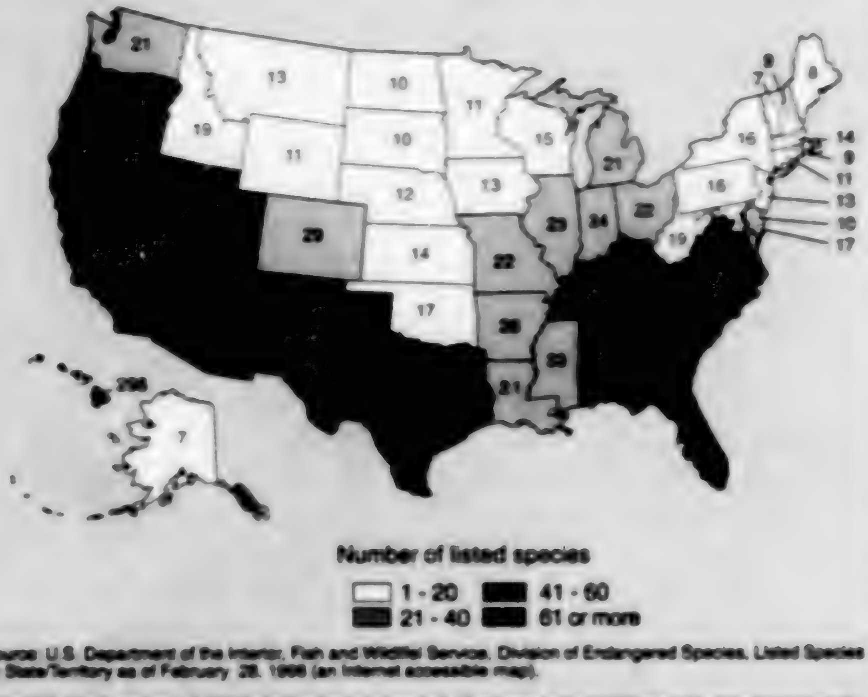
PROTECTING COASTAL SPECIES AT RISK

Of the 1,126 species of plants and animals in the nation that are listed as threatened or endangered (as of February 1998), half or more are found within coastal states (Figure 6.16). There are numerous causes of these species' decline, including habitat loss, unwise forestry and agricultural practices, overharvesting and exploitation, dredging and filling of wetlands, development in ecologically sensitive areas, and the introduction of non-native species.

Many projects are underway to assist species at risk. For example:

- At the Dare County Air Force Base in Dare County, North Carolina, stands of Atlantic white cedar have not been able to fully re-establish themselves since extensive logging operations in the 1880s. The Air Force and several other partners are beginning a $500,000 project that will identify the factors in cedar forests that are critical to successful, natural reforestation. A variety of methods of naturally introducing white cedar will be evaluated, including the cultivation of cones, seeds, and seedlings. The project will produce guidelines for restoring traditional white cedar ecosystems.
- Protection of the manatee is a high priority for the South Florida Water Management District. Between 1974 and 1993, 73 manatees died in the Okeechobee Waterway and in the Central and South Florida Flood Control Project locks and water control structures. In partnership with the

Figure 6.16 U.S. Listed Threatened and Endangered Species by State



Source: U.S. Department of the Interior, Fish and Wildlife Service, Division of Endangered Species, Listed Species by State/Territory as of February 28, 1998 (an Internet accessible map).

Note: U.S. listed species = 1,135 (including 8 whale species). Numbers are not additive; a species often occurs in more than one state. Omits "similarity of appearance" and some extirpated species. Numbers on map do not include whales and non-nesting sea turtles in coastal waters. Not shown are the number of listed species in the District of Columbia (3); Puerto Rico (71); U.S. Virgin Islands (11); and other Pacific islands (16).

Corps of Engineers and others, automatic gate reversal sensors are currently being designed, tested and installed on lock sector gates and spillway gates. Whenever manatees are caught by a closing gate, the sensors would automatically stop and reverse the gate closure before the animal is injured or killed.

- The Aransas National Wildlife Refuge on the Gulf Coast of Texas, which is a seasonal home for the endangered whooping crane, is immediately adjacent to the Gulf Intercoastal Waterway. Since 1950, the refuge may have lost as much as 1,000 acres of crane habitat as a result of bank erosion caused by boat wakes from commercial and recreational vessels, wind-driven waves, and storms. To temporarily stem the erosion, the Fish and Wildlife Service and many other partners worked from 1989 to 1992 to install anchored cement bags along 3,850 feet of channel bank, thus protecting about 100 acres of salt marsh. The project attracted strong local support; some 500 non-federal volunteers contributed over 7,000 hours to the effort. The Corps is developing a proposal for a more permanent solution to the channel erosion problem.

- The snowy plover, which was listed as threatened by the state of Oregon in 1975 and added to the federal threatened list in 1990, has been declining in part because the growth of European beachgrass along the coast has eliminated much of the flat, open, sandy beaches required by the plover for nesting. At the Umpqua River North Spit within the Oregon Dune National Recreation Area near Reedport, a project completed in the fall of 1994 created approximately 10 acres of sustainable nesting habitat for the plover. The project created the habitat using clean dredged sediments removed from the Winchester Bay federal navigation project. (For examples of DoD beach and dune restoration, see Box 6.3.)

Successful projects in species protection in the last few years have identified some valuable lessons about process. For example, the migratory bird treaties with Canada, Japan, Mexico and Russia have enabled many federal agencies to justify their participation in collaborative activities dealing with neotropical songbirds, migratory waterfowl, and shorebirds. Public-private partnerships between groups such as The Nature Conservancy and federal agencies have contributed to a balanced blending of private funding for this work.

In many projects, volunteers have provided a significant source of both labor and expertise. Active public participation can not only help accomplish a project, but can also improve the public's awareness of environmental problems and the restoration process.

NEW STRATEGIES

As the complex nature of coastal environmental predicaments has become clear, resourceful groups and individuals have come up with new ways to marshal resources and share responsibilities. These new strategies represent attempts to meet the goals of water quality and

Rivers meet the sea along the rocky Maine shore.

Photo Credit
USDA—93CS0380

Box 6.3
DoD Works to Restore Beaches and Dunes

Beaches and dunes are often relatively fragile structures built from sediment carried down rivers, transported along coasts by nearshore currents, and redistributed by tides and wave action. They provide a first line of protection during storms by buffering wind and wave energy. They can be easily disturbed both by human activities and by natural factors such as major storms.

Many Defense Department agencies are actively engaged around the nation in beach and dune restoration projects.

At Tyndall Air Force Base on the northwest coast of Florida near Panama City, wind damage and human use has severely eroded the primary dune system and is threatening the interior dunes. Using funds from the Defense Department's Legacy Resource Management Program, the project has installed an elevated boardwalk system and picnic areas for visitors. To protect the dunes from further wind damage, sand fences were installed along with plantings of native vegetation.

The Florida Department of Environmental Protection participated in the Tyndall project and plans to take similar measures on the adjoining state park. Nongovernment partners included the Sea Oats Garden Club and Friends of St. Joe Bay.

On the east coast of Florida near the city of Cocoa Beach, Patrick Air Force Base is located on a barrier island that has been eroding badly during storms. The erosion was threatening coastal habitats and threatening to degrade the Indian River Lagoon National Estuary. A plan was developed to regrade the shoreline and install large coquina rocks over filter cloth combined with the planting of mangroves and other native species. Project partners included the Fish and Wildlife Service, Corps of Engineers, National Marine Fisheries Service, Florida Department of Environmental Protection, Florida Marine Resources Council, St. John's River Water Management District, and the Indian River Lagoon National Estuary Program.

In 1991, a severe winter freeze destroyed the vegetation on about 44 acres of coastal dunes near the city of Monterey, California, and the nearby Naval Postgraduate School. Without this protective cover, the dunes were in jeopardy of shifting and causing severe damage to the Navy's facilities and to adjacent private properties. As part of its "good neighbor" policy with the city, the Navy provided $295,000 for a project to restore the dunes.

The vegetation that had succumbed consisted mostly of the exotic African ice plant, which has poor tolerance for freezing temperatures. The city and the Navy agreed to remove all the exotic vegetation with the help of volunteers from the Monterey Dune Coalition and the Big Sur Land Trust. Over 150,000 seedlings, including 26 species of native vegetation, were planted on the dunes. The native plants should enhance the habitat for endangered species known to frequent the area such as Smith's blue butterfly. Furthermore, the use of native vegetation should reduce the risk of vegetative loss in the event of another freeze.

The project has been endorsed for its use of native plant material by the California Coastal Commission, the Fish and Wildlife Service, the Monterey Dune Coalition, the Big Sur Land Trust, and the California Native Plant Society.

utility through collaborative agreements based on science, innovation, and new institutional arrangements.

One new approach, point/nonpoint and point/point source trading, is being tried in the Tar-Pamlico Basin in North Carolina. Another important breakthrough is the recognition of the contribution made by air deposition to water quality problems, which is being addressed by the Tampa Bay National Estuary Program.

Reducing Pollutants in the Tar-Pamlico Basin

Over the past three decades, high levels of nutrients (mostly nitrogen and phosphorus) flowing from the Tar-Pamlico River into the Tar-Pamlico estuary in North Carolina have increased algal levels (measured by chorophyll a) in the estuary, causing fish kills and generally diminished water quality. Studies indicate that about 90 percent of the nitrogen entering the river is from nonpoint sources, largely from agricultural sources. The 5,400-square-mile watershed includes five of the state's ten leading hog-producing counties and the leading poultry-producing county. About 37 percent of the watershed's area is farmland, mostly in row-crop production. Prior to a modeling effort, discharges to the basin of the overall nitrogen and phosphorus load were estimated at 15-20 percent. Once modeling tests were completed, municipal wastewater discharges to the basin were estimated to contribute about 8 percent of the overall nitrogen and phosphorus load to the estuary.

In 1979, the North Carolina Environmental Management Commission adopted a water quality standard for chlorophyll a of 40 micrograms per liter (ug/l) for lakes, estuaries, sounds, and other slow-moving waters. Since algal blooms with chlorophyll a densities ranging from 40 to 300 ug/l were not unusual in the Tar-Pamlico during the summer months, the new standard meant that state regulators would have to do something about algal blooms in the Tar-Pamlico estuary.

In the late 1980s the state made progress on phosphorus discharges, passing a statewide ban on the sale of phosphate detergents in 1988 and issuing a new permit for Texasgulf Industries, Inc., which alone was responsible for 50 percent of the phosphorus discharged into the estuary. The new permit required Texasgulf to reduce its phosphorus loadings by 90 percent, which the company achieved by March 1994.

Even as the state was making progress on phosphorus, the problem with nitrogen pollution was continuing. A 1988 study indicated that about 83 percent of the nitrogen load came from nonpoint sources, mostly agriculture, and only 17 percent came from point sources.

To meet North Carolina's stringent proposed point source limitations, dischargers would have to build expensive new advanced treatment facilities. The Tar-Pamlico Basin Association, which included 12 municipalities and one industry in the watershed, estimated capital costs for implementing the nutrient control measures at $50 million plus additional operation and maintenance costs. Many were troubled by these high

treatment costs, especially given the relatively small impact of point source nutrient removal on overall nutrient emissions into the estuary.

In response to the state's proposed nutrient management strategy, the Tar-Pamlico Association proposed to develop an alternative strategy that would more cost-effectively address both point and nonpoint sources of pollution. Working with the state, the North Carolina Environmental Defense Fund, and the Pamlico-Tar River Foundation, the association proposed several steps: immediate nutrient load reductions through improved treatment plant performance; development of an estuary model to evaluate nutrient impacts, alternative pollution control strategies, and set nutrient loading targets; establishment of a mass-based cumulative discharge cap for all members; establishment of a schedule of short-term nutrient reduction goals; development of a management framework to target and track nonpoint sources; and initiation of a best management practices (BMPs) pilot program to demonstrate the efficacy of a point/nonpoint source trading program. In December 1989, after considerable debate, the state approved the alternative strategy. Phase I (1990-94) identified the actions and implementation schedule necessary for the new approach. In Phase II (1995-2004), trading can occur to avoid nitrogen and phosphorus load increases into the estuary.

Having established a baseline discharge level of 625,000 kg/year, the association members agreed to a total nutrient reduction of 200,000 kilograms (of both nitrogen and phosphorus) during the program's first phase.

The association hired a consulting firm to identify immediate and relatively low-cost facility improvements and assess the relative capabilities of different treatment processes. With the help of this analysis, the association members were able to meet the Phase I reduction targets simply by optimizing existing treatment works and maximizing the performance of expansion projects. The study also established the limits of the existing treatment works to achieve nutrient reduction; further reductions could only be achieved with expensive capital modifications or other more energy- or chemical-intensive alternatives.

In the initial stages of this point-nonpoint trading program, the association agreed to pay $56 for each kilogram of nutrients discharged above the group's yearly nutrient reduction targets, with the funds paid into a nonpoint source control fund administered by the state's existing agricultural cost-share program. The figure was derived by the state based on the average nonpoint source control cost in a nearby watershed and included a 3:1 safety factor for cropland BMPs and 2:1 for confined animal operations.

A subsequent study by the Research Triangle Institute found that the $56/kg figure generally overestimated the cost of nitrogen removal. In Phase II, the parties agreed to revise the figure to $29/kg, with the figure to be evaluated and adjusted as necessary every two years.

Once the high-priority BMPs are addressed, it is likely that the cost of nitrogen reduction via BMPs will

increase. Nevertheless, the current \$29/kg cost estimate for nitrogen removal supports the conclusion that implementing BMPs may be a more cost-effective means to achieve nutrient reduction than further point source controls.

Identifying Air-Water Linkages

The contribution of atmospheric pollution to water pollution is significant. For example, about 54 percent of the nitrogen emitted from fossil-fuel-burning plants, vehicles, and other sources in the United States is deposited on U.S. watersheds and coastal estuaries. The largest sources are point sources: coal- and oil-fired electric utilities and large industries. Mercury and other toxics also are atmospheric pollutants that affect water quality.

Atmospheric-borne nitrogen is a major contributor to nitrogen loadings in many estuaries. About 27 percent of the nitrogen in the Chesapeake Bay is from the atmosphere, while the atmospheric contribution in the Albemarle/Pamlico Sound is estimated at about 44 percent.

In 1996, EPA and its partners began a new initiative to bring Clean Air Act and Clean Water Act activities into closer coordination and address air deposition to the nation's waters and coastal watersheds. For example, the Tampa Bay National Estuary Program, recognizing the impacts of air deposition of nitrogen on water quality in Tampa Bay, convened a Nitrogen Management Consortium to address nitrogen loadings to the Bay that come from atmospheric deposition—in addition to the more traditionally recognized municipal and industrial point sources. The Consortium is developing a novel plan under which the group as a whole will come up with individual and/or joint projects to achieve the reductions deemed necessary to preserve the water quality gains already achieved in the rapidly growing Tampa Bay area.

GLOBAL LINKAGES

In a great many cases, the fate of the nation's environment and resources depends critically on developments well beyond the nation's borders. All the effort to protect the habitat of migratory songbirds in the United States, for example, may not be sufficient if their winter habitat in Central and Latin America is lost. Each country's attempt to protect marine resources, the stratospheric ozone layer, and the global climate cannot succeed without the cooperation of all the world's nations.

Climate Change

The scientific evidence that climate change is occurring is now clear and compelling. Emissions of greenhouses gases—mainly carbon dioxide—from human activities are amplifying the Earth's natural greenhouse effect and are leading to a warming of the planet's surface. Climate change is likely to lead to a series of global disruptions, including sea-level rise, changing patterns of precipitation, shifts in atmospheric and ocean currents, and changes in the ideal ranges for plants and animals.

Photo Credit
S.C. Delaney/EPA

Increased variability of the hydrologic cycle is expected to result in more severe droughts and/or floods in some regions. Climate change would likely add to the stress in U.S. river basins, particularly the Great Basin, California, Missouri, Arkansas, Texas Gulf, Rio Grande, and Lower Colorado. Reductions in runoff of up to 25 percent in the Colorado River Basin are projected under some scenarios. In the United States, the regional impacts of climate change are potentially very serious:

- In the Northeast, sugar maples and beech trees may move completely into Canada, with considerable economic impact. Coastal areas are likely to be affected by intensifying storms, sea-level rise, and reduced freshwater input to estuaries.
- In the Southeast, the low elevation of states such as Florida makes this region especially vulnerable to sea-level rise and storm surges during hurricanes, which are expected to worsen with climate change. A 1-foot rise in sea level, the best estimate over the next century, could erode 100 to 1,000 feet of Florida's beaches, damaging property and the tourism industry. A 20-inch rise could inundate more than 5,000 square miles of dry land and an additional 4,000 square miles of wetlands along U.S. coasts, while a 3-foot rise could inundate much of the southern tip of Florida. Precipitation

changes and salt-water intrusion from sea-level rise could adversely affect the ecological communities of the Florida Everglades and degrade the habitat for many wading birds.

- In the Great Plains, the simultaneous drop in aquifer levels (largely as a result of demand from the agricultural sector), greater run-off from extreme downpours, and shorter duration of snow cover will exacerbate the region's water supply problems. Riparian areas are extremely vulnerable to warmer, drier climate.
- In the Southwest, the region's vulnerability to water supply problems is likely to worsen. The region is expected to experience more extremely hot days, fewer cool days, and decreased winter precipitation. Alteration of the region's hydrologic cycle would affect both quantity and quality of water supply, with major implications for continued development.
- In the Pacific Northwest, changing patterns of precipitation and drought, timing of runoff, and increased inundation of coastal areas due to sea-level rise is expected. In the Columbia River Basin, where an overall decrease in annual run-off is likely, competition among hydropower production, fisheries production, and irrigation will probably increase.
- In Alaska, probable consequences include drying of Alaska's interior, inundation of fragile coastal delta areas, and, most seriously, melting of permafrost, which is already underway. In many cases, ground level can collapse 5 yards or more, leading to significant damages to ecosystems and human infrastructure. Ecosystem effects include expansion of lakes and wetlands, clogging of salmon-spawning streams, and increased rates of coastal and riverbank erosion.

The principal hope for dealing with climate change is The Framework Convention on Climate Change, which seeks to stabilize atmospheric concentrations at levels that prevent dangerous human-induced interference with the climate system. At the latest meeting of the parties in Kyoto, Japan, in December 1997, industrialized nations agreed to legally binding emissions reduction targets with a view to reducing their overall emissions of six greenhouse gases by approximately 5 percent below 1990 levels in the period 2008-2012. The U.S. succeeded in ensuring that countries could achieve their emission targets as cost-effectively as possible through market-based implementation mechanisms. Many issues are still outstanding, however, and remain for further negotiation.

The State of the Oceans

Concern about the state of the world's oceans is growing. Early in 1998, some 1,600 scientists from 65 countries issued a statement warning of the increasing threats to the world's oceans. The statement noted that life in the world's estuaries, coastal waters, enclosed seas and oceans is increasingly threatened by overexploitation of species, physical alteration of ecosystems, pollution, introduction of

alien species, and global atmospheric change.

Of the many factors contributing to the crisis, the statement noted that fishing practices such as bottom trawling are degrading habitat for bottom-dwelling creatures; that overexploitation is threatening species such as swordfish; that land-based pollutants such as PCBs and other pollutants are threatening shellfish; and that human activities seem linked to emerging epidemic diseases that are sweeping through marine species from corals to dolphins.

In recognition of the importance of the ocean and the marine environment, the United Nations has declared 1998 to be the International Year of the Ocean. Many events are planned in the United States in 1998, including a national conference to discuss a wide range of ocean-related issues.

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228

Part III

Environmental Data and Trends

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List of Tables

Pollution Prevention

Energy

Transportation

Global Atmosphere and Climate

Population

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Table 1.1 U.S. Population and Population Growth Rate, 1900-1996

Year	Population	Growth rate	Year	Population	Growth rate	Year	Population	Growth rate
	millions	%		*millions*	%		*millions*	%
1900	76.09	na	1933	125.69	0.6	1966	196.56	1.1
1901	77.58	2.0	1934	126.49	0.7	1967	198.71	1.1
1902	79.16	2.0	1935	127.36	0.7	1968	200.71	1.0
1903	80.63	1.9	1936	128.18	0.6	1969	202.68	1.0
1904	82.17	1.9	1937	128.96	0.7	1970	205.05	1.3
1905	83.82	2.0	1938	129.97	0.8	1971	207.66	1.2
1906	85.45	1.9	1939	131.03	0.8	1972	209.90	1.0
1907	87.01	1.8	1940	132.59	0.9	1973	211.91	0.9
1908	88.71	2.0	1941	133.89	1.0	1974	213.85	0.9
1909	90.49	2.0	1942	135.36	1.3	1975	215.97	1.0
1910	92.41	2.1	1943	137.25	1.3	1976	218.04	1.0
1911	93.86	1.6	1944	138.92	1.2	1977	220.24	1.0
1912	95.34	1.6	1945	140.47	1.0	1978	222.59	1.1
1913	97.23	2.0	1946	141.94	1.5	1979	225.06	1.1
1914	99.11	1.9	1947	144.70	1.8	1980	227.73	1.2
1915	100.55	1.4	1948	147.21	1.7	1981	229.97	1.0
1916	101.96	1.4	1949	149.77	1.7	1982	232.19	1.0
1917	103.41	1.4	1950	152.27	1.7	1983	234.31	0.9
1918	104.55	1.1	1951	154.88	1.7	1984	236.35	0.9
1919	105.06	0.5	1952	157.55	1.7	1985	238.47	0.9
1920	106.46	1.3	1953	160.18	1.7	1986	240.65	0.9
1921	108.54	2.0	1954	163.03	1.8	1987	242.80	0.9
1922	110.05	1.4	1955	165.93	1.8	1988	245.02	0.9
1923	111.95	1.7	1956	168.90	1.8	1989	247.34	0.9
1924	114.11	1.9	1957	171.98	1.7	1990	249.91	1.0
1925	115.83	1.5	1958	174.88	1.7	1991	252.65	1.1
1926	117.40	1.4	1959	177.83	1.7	1992	255.42	1.1
1927	119.04	1.4	1960	180.67	1.6	1993	258.14	1.1
1928	120.51	1.2	1961	183.69	1.6	1994	260.66	1.0
1929	121.77	1.0	1962	186.54	1.5	1995	263.03	0.9
1930	123.19	0.9	1963	189.24	1.4	1996	265.56	1.0
1931	124.15	0.7	1964	191.89	1.3			
1932	124.95	0.6	1965	194.30	1.2			

Sources: U.S. Department of Commerce, Bureau of the Census, *Estimates of the Population of the United States to December 31, 1995* (GPO, Washington, DC, 1995).

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Notes: The population estimates shown here are based on the April 1, 1990, population as enumerated in the 1990 census. Estimates for dates prior to April 1, 1990, have been revised. Annual population estimates are for July 1 of each year. Total population for the years 1900-1916 and 1920-1929 are resident population. Total population for the years 1917-1919, 1930-1939, and 1940-1996 are resident population plus armed forces overseas. All years 1903-1939 exclude Alaska and Hawaii.

Table 1.2 Components of U.S. Population Change, 1940-1996

Year	Births	Deaths	Net civilian immigration	Net change
		millions		
1940	2.570	1.432	0.077	1.221
1945	2.873	1.549	0.162	1.462
1950	3.645	1.468	0.299	2.486
1955	4.128	1.537	0.337	2.925
1960	4.307	1.708	0.328	2.901
1965	3.801	1.830	0.373	2.315
1970	3.739	1.927	0.438	2.617
1975	3.144	1.894	0.449	2.165
1980	3.612	1.990	0.845	2.510
1985	3.761	2.086	0.649	2.171
1990	4.148	2.155	0.556	2.549
1996	3.850	2.349	0.827	2.328

Source: U.S. Department of Commerce, Bureau of the Census, *U.S. Population Estimates, by Age, Sex, Race, and Hispanic Origin*, Current Population Reports, Series P-25, No. 1045 (1990) and No. 1095 (1993) (GPO, Washington, DC), Population Paper Listings, PPL-57 (DOC, Census, Washington, DC, 1997), and updates by agency.

Note: Annual population estimates are for July 1 of each year.

Table 1.3 Age Structure of the U.S. Population, including Armed Forces Overseas, 1940-1996

Year	< 5	5-14	15-24	25-34	35-44	45-54	55-64	> 64
				Age classes, in years				
					millions			
1940	10.6	22.3	24.0	21.5	18.4	15.6	10.7	9.0
1955	16.3	24.5	22.3	23.9	21.6	17.4	13.4	12.4
1960	20.3	35.7	24.6	22.9	24.2	20.6	15.6	16.7
1970	17.2	40.7	36.5	25.3	23.1	23.3	18.7	20.1
1980	16.5	34.8	42.8	37.6	25.9	22.7	21.8	25.7
1985	17.8	33.7	40.2	41.9	31.8	22.5	22.1	28.4
1990	18.8	35.2	36.9	43.1	37.8	25.2	21.1	31.2
1996	19.3	38.4	36.2	40.4	43.4	33.4	21.4	33.9

Sources: U.S. Department of Commerce, Bureau of the Census, *Historical Statistics of the United States: Colonial Times to 1970*, Part I, Series A 30-37 (GPO, Washington, DC, 1975).

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Note: Annual population estimates are for July 1 of each year.

Table 1.4 U.S. Population in Urban, Suburban, and Rural Areas, 1950-1994

Year	Urban population		Suburban population		Rural population	
	millions	%	*millions*	%	*millions*	%
1950	49.661	32.8	35.193	23.3	66.472	43.9
1960	58.004	32.3	54.881	30.6	66.438	37.0
1970	63.797	31.4	75.622	37.2	63.793	31.4
1980	67.949	30.0	101.481	44.8	57.115	25.2
1990	77.844	31.3	114.882	46.2	55.984	22.5
1994	75.591	29.4	129.063	50.1	52.687	20.5

Source: U.S. Department of Commerce, Bureau of the Census, Census of Population and Housing, 1950, 1960, 1970, 1980, and 1990, Number of Inhabitants, U.S. Summary (GPO, Washington, DC) and updates by agency.

Notes: Urban refers to population inside central cities of metropolitan areas (MAs). Suburban refers to MA population in suburbs outside central cities. Rural refers to nonmetropolitan population. MAs are defined for each population census.

Table 1.5 U.S. Population by Region, 1900-1996

Year	Northeast	Midwest	South	West
		regional population, in millions		
1900	21.047	26.333	24.524	4.309
1910	25.869	29.889	29.389	7.082
1920	29.662	34.020	33.126	9.214
1930	34.427	38.594	37.858	12.324
1940	35.977	40.143	41.666	14.379
1950	39.478	44.461	47.197	20.190
1960	44.678	51.619	54.973	28.053
1970	49.061	56.590	62.813	34.838
1980	49.137	58.867	75.367	43.171
1990	50.809	59.669	85.446	52.786
1996	51.580	62.082	93.098	58.524

Sources: U.S. Department of Commerce, Bureau of the Census, *1990 Census of Population and Housing*, CPH-2-1 (GPO, Washington, DC, 1993).

--, *Estimates of the Population of States: July 1, 1990 to July 1, 1996*, CB96-224 (GPO, Washington, DC, 1996).

Table 1.6 U.S. Population Migration by Region, 1960-1996

Region	1960-1970	1970-1980	1980-1990	1990-1996
	net migration gains and losses, in millions			
Northeast	0.324	-2.888	-0.592	-2.115
Midwest	-0.752	-2.703	-2.293	-0.290
South	0.593	5.992	5.143	2.529
West	2.855	4.115	4.568	-0.125

Sources: U.S. Department of Commerce, Bureau of the Census, *1990 Census of Population and Housing*, CPH-2-1 (GPO, Washington, DC, 1993).

--, *Estimates of the Population of States: July 1, 1990 to July 1, 1996*. CB96-224 (GPO, Washington, DC, 1996).

Notes: Migration is that portion of population change not attributed to births and deaths. Net migration is the difference between domestic immigration to an area and outmigration from it during the period.

Table 1.7 U.S. Population Density, 1960-1996

Year	Total United States	Counties in coastal regions: Pacific	Gulf of Mexico	Atlantic	Great Lakes	Interior of U.S.
		Land area, in thousands of square miles				
1994	3,536.3	509.9	114.5	147.8	115.4	2,648.7
		Population, in millions				
1960	179.3	17.9	8.4	44.5	23.7	84.8
1970	203.3	22.8	10.0	51.1	26.0	93.3
1980	226.5	27.0	13.1	53.7	26.0	106.7
1990	248.7	33.2	15.2	59.0	26.9	115.3
1994	260.3	35.1	16.3	60.7	26.4	121.8
1996	265.3	35.6	16.7	61.4	26.5	125.0
		Population per square mile				
1960	50.7	35.1	73.4	301.1	205.4	32.0
1970	57.5	44.7	87.3	345.7	225.3	35.2
1980	64.0	53.0	114.4	363.3	225.6	40.3
1990	70.3	66.1	136.2	399.2	224.8	43.5
1994	73.6	68.8	142.9	410.7	228.8	46.0
1996	75.0	69.8	145.9	415.4	229.6	47.2

Source: U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States, 1997* (GPO, Washington, DC, 1997).

Notes: Coastal area includes 672 counties and independent cities with at least 15 percent of their land area either in a coastal watershed or in a coastal cataloging unit defined in 1992 by the National Oceanic and Atmospheric Administration.

Table 1.8 U.S. Population Below Poverty Level by Race, Residence, and Region, 1969-1996

	Total		Race			Residence			Region			
Year	Number millions	Rate %	White	African American	Hispanic origin	MA central city	MA suburb millions	Rural	Northeast	Midwest	South	West
1969	24.15	12.1	16.66	7.10	na	7.99	5.09	11.06	4.11	5.42	11.09	3.53
1970	25.42	12.6	17.48	7.55	na	8.12	5.20	12.10	na	na	11.48	na
1971	25.56	12.5	17.78	7.40	na	8.91	5.65	11.00	4.51	5.76	11.18	4.10
1972	24.46	11.9	16.20	7.71	na	9.18	5.33	9.95	4.27	5.26	10.93	4.01
1973	22.97	11.1	15.14	7.39	2.37	8.59	5.17	9.21	4.21	4.86	10.06	3.84
1974	23.37	11.2	15.74	7.18	2.58	8.37	5.48	9.52	4.47	4.99	10.76	4.04
1975	35.88	12.3	17.77	7.55	2.99	9.09	6.26	10.53	4.90	5.46	11.06	4.45
1976	24.98	11.8	16.71	7.60	2.78	9.48	5.75	9.75	4.95	5.66	10.35	4.02
1977	24.72	11.6	16.42	7.73	2.70	9.20	5.66	9.86	4.96	5.59	10.25	3.93
1978	24.50	11.4	16.26	7.63	2.61	9.29	5.81	9.41	5.05	5.19	10.26	4.00
1979	26.07	11.7	17.21	8.05	2.92	9.72	6.42	9.94	5.03	5.59	10.63	4.10
1980	29.27	13.0	19.70	8.58	3.49	10.64	7.38	11.25	5.37	6.59	12.36	4.96
1981	31.82	14.0	21.55	9.17	3.71	11.23	8.12	12.48	5.82	7.14	13.26	5.61
1982	34.40	15.0	23.52	9.70	4.30	12.70	8.55	13.15	6.36	7.77	13.97	6.30
1983	35.30	15.2	23.98	9.88	4.63	12.87	8.88	13.52	6.56	8.54	13.48	6.68
1984	33.70	14.4	22.96	9.49	4.81	na	na	na	6.53	8.30	12.79	6.07
1985	33.06	14.0	22.86	8.93	5.24	14.18	9.10	9.79	5.75	8.19	12.92	6.20
1986	32.37	13.6	22.18	8.98	5.12	13.30	9.36	9.71	5.21	7.64	13.11	6.41
1987	32.22	13.4	21.20	9.52	5.42	13.70	9.36	9.17	5.48	7.50	13.29	6.29
1988	31.75	13.0	20.72	9.36	5.36	13.62	9.44	8.69	5.09	6.80	13.53	6.32
1989	31.53	12.8	20.79	9.30	5.43	13.59	9.33	8.61	5.06	7.04	12.94	6.48
1990	33.59	13.5	22.33	9.84	6.01	14.25	10.26	9.08	5.79	7.46	13.46	6.88
1991	35.71	14.2	23.75	10.24	6.34	15.31	11.51	8.88	6.18	7.99	13.78	7.76
1992	38.01	14.8	25.26	10.83	7.59	16.35	12.03	9.63	6.41	8.06	15.20	8.34
1993	39.27	15.1	26.23	10.88	8.13	16.81	12.81	9.65	6.84	8.17	15.38	8.88
1994	38.06	14.5	25.38	10.20	8.42	16.10	13.51	8.45	6.60	7.97	14.73	8.77
1995	36.43	13.8	24.42	9.87	8.57	16.27	12.07	8.08	6.45	6.79	14.46	8.74
1996	36.53	13.7	24.05	9.69	8.70	15.65	12.57	8.32	6.56	6.65	14.10	9.22

Source: U.S. Department of Commerce, Bureau of the Census, *March Current Population Survey* (DOC, Census, Washington, DC, 1997).

Notes: na = not available. Poverty rate = percent of persons below poverty level. MA = Metropolitan Area. Total includes other races not shown separately. Persons of Hispanic origin may be of any race. Poverty rate for all races for years not shown are: 1959, 22.4; 1960, 22.2; 1961, 21.9; 1962, 21.0; 1963, 19.5; 1964, 19.0; 1965, 17.3; 1966, 14.7; 1967, 14.2; and 1968, 12.8. Poverty thresholds are updated annually to reflect changes in the consumer price index.

BLANK PAGE

Economy and the Environment

245

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Table 2.1 U.S. Gross Domestic Product, 1959-1996

Year	Gross domestic product: Current dollars (billions)	Gross domestic product: Chained (1992) dollars (billions)	Price deflators for GDP (1992=100)
1959	507.2	2,210.2	23.0
1960	526.6	2,262.9	23.3
1961	544.8	2,314.3	23.5
1962	585.2	2,454.8	23.8
1963	617.4	2,559.4	24.1
1964	663.0	2,708.4	24.5
1965	719.1	2,881.1	25.0
1966	787.8	3,069.2	25.7
1967	833.6	3,147.2	26.5
1968	910.6	3,293.9	27.6
1969	982.2	3,393.6	29.0
1970	1,035.6	3,397.6	30.5
1971	1,125.4	3,510.0	32.1
1972	1,237.3	3,702.3	33.4
1973	1,382.6	3,916.3	35.3
1974	1,496.9	3,891.2	38.5
1975	1,630.6	3,873.9	42.1
1976	1,819.0	4,082.9	44.6
1977	2,026.9	4,273.6	47.4
1978	2,291.4	4,503.0	51.0
1979	2,557.5	4,630.6	55.2
1980	2,784.2	4,615.0	60.3
1981	3,115.9	4,720.7	66.0
1982	3,242.1	4,620.3	70.2
1983	3,514.5	4,803.7	73.2
1984	3,902.4	5,140.1	75.9
1985	4,180.7	5,323.5	78.5
1986	4,422.2	5,487.7	80.6
1987	4,692.3	5,649.5	83.1
1988	5,049.6	5,865.2	86.1
1989	5,438.7	6,062.0	89.7
1990	5,743.8	6,136.3	93.6
1991	5,916.7	6,079.4	97.3
1992	6,244.4	6,244.4	100.0
1993	6,558.1	6,389.6	102.6
1994	6,947.0	6,610.7	105.1
1995	7,265.4	6,742.1	107.8
1996	7,636.0	6,928.4	110.2

Source: U.S. Department of Commerce, Bureau of Economic Analysis, "Summary National Income and Product Series, 1929-96," *Survey of Current Business* (GPO, Washington, DC, August 1997).

Table 2.2 U.S. Pollution Abatement and Control Expenditures by Function, 1972-1994

Year	Pollution abatement		Regulation & monitoring		Research & development		Total	
	billion dollars	*price index*	*billion dollars*	*price index*	*billion dollars*	*price index*	*billion dollars*	*price index*
1972	15.45	31.5	0.37	31.6	0.82	30.0	16.64	31.5
1973	17.93	34.5	0.49	33.8	0.90	31.9	19.33	34.5
1974	21.85	40.6	0.60	37.6	0.99	35.4	23.43	40.4
1975	26.55	43.8	0.65	40.2	1.10	39.2	28.30	43.6
1976	29.80	46.3	0.73	42.4	1.28	41.8	31.80	46.2
1977	32.79	49.4	0.83	45.9	1.48	44.8	35.10	49.3
1978	36.90	53.2	0.95	49.0	1.65	48.6	39.50	53.0
1979	42.43	61.0	1.07	52.9	1.78	53.2	45.27	59.8
1980	47.75	67.9	1.26	58.9	1.75	59.8	50.76	67.4
1981	51.39	74.8	1.31	64.7	1.71	66.4	54.41	74.3
1982	52.99	77.8	1.32	69.7	1.64	71.5	55.95	77.5
1983	56.23	80.3	1.30	73.0	1.60	74.8	59.12	80.0
1984	63.26	82.8	1.29	75.7	1.51	77.6	66.06	82.5
1985	68.73	85.2	1.25	78.5	1.38	79.5	71.36	84.9
1986	72.91	84.8	1.46	81.4	1.67	80.5	76.04	84.6
1987	75.61	86.8	1.65	84.2	1.69	82.3	78.95	86.6
1988	80.55	89.3	1.66	86.4	1.54	86.3	83.75	89.2
1989	85.10	92.8	1.73	89.5	1.68	90.0	88.51	92.7
1990	91.61	96.1	1.79	92.9	1.42	93.0	94.82	95.9
1991	93.75	98.3	2.29	97.3	1.87	96.6	97.90	98.2
1992	100.46	100.0	2.80	100.0	1.56	100.0	104.83	100.0
1993	105.84	102.6	2.34	101.9	1.87	102.9	110.05	102.6
1994	117.62	106.0	2.20	101.5	1.99	103.2	121.81	105.8

Source: Vogan, C.R., "Pollution Abatement and Control Expenditures, 1972-94," *Survey of Current Business* (GPO, Washington, DC, September 1996).

Notes: Dollars = current dollars. Price index = chained-type price index, 1992 = 100. Expenditures are for goods and services that U.S. residents use to produce cleaner air and water and to manage solid waste. Pollution abatement directly reduces emissions by preventing the generation of pollutants, by recycling the pollutants, or by treating the pollutants prior to discharge. Regulation and monitoring are government activities that stimulate and guide action to reduce pollutant emissions. Research and development by business and government not only support abatement but also help increase the efficiency of regulation and monitoring. Totals may not agree with sum of components due to independent rounding. This series was discontinued after 1994.

Table 2.3 U.S. Pollution Abatement and Control Expenditures by Type, 1972-1994

Year	Air		Water		Solid waste		Other	
	billion dollars	*price index*	*billion dollars*	*price index*	*billion dollars*	*price index*	*billion dollars*	*price index*
1972	6.43	32.5	7.21	32.1	3.18	30.4	-0.19	38.3
1973	7.68	34.9	8.21	36.0	3.59	32.7	-0.15	49.8
1974	9.68	43.3	9.77	40.9	4.18	36.5	-0.19	72.0
1975	11.92	47.3	12.07	43.7	4.52	39.2	-0.22	76.2
1976	13.03	49.4	14.06	46.7	5.00	41.7	-0.28	77.3
1977	14.72	52.6	14.96	50.2	5.72	44.1	-0.29	79.1
1978	16.38	56.1	17.00	54.8	6.51	46.6	-0.39	85.8
1979	19.40	65.0	19.19	60.7	7.28	51.6	-0.59	103.9
1980	22.35	76.5	20.64	66.4	8.52	56.4	-0.75	122.2
1981	25.42	84.0	20.15	72.5	9.69	64.0	-0.86	130.6
1982	25.96	86.1	20.70	76.1	9.80	68.4	-0.52	120.3
1983	26.68	87.3	21.71	79.9	11.12	70.9	-0.39	111.1
1984	29.42	88.9	24.18	83.1	13.03	74.0	-0.56	111.9
1985	30.68	90.5	26.17	86.2	15.18	76.7	-0.66	103.2
1986	31.43	87.4	28.23	86.9	17.06	79.1	-0.69	92.7
1987	29.36	89.5	30.76	88.5	19.43	81.7	-0.61	96.8
1988	31.33	91.6	31.29	91.1	22.43	85.0	-1.30	102.7
1989	29.34	94.8	33.68	94.2	26.66	89.4	-1.17	108.3
1990	28.33	97.3	37.13	96.7	30.64	94.2	-1.28	111.1
1991	27.79	98.7	37.92	98.9	32.83	97.3	-0.63	104.0
1992	29.79	100.0	39.07	100.0	36.58	100.0	-0.81	100.0
1993	32.48	101.6	39.38	103.8	38.37	102.2	-0.18	0.97
1994	37.60	104.6	42.38	108.1	41.74	104.6	+0.09	-0.91

Source: Vogan, C.R., "Pollution Abatement and Control Expenditures, 1972-94," *Survey of Current Business* (GPO, Washington, DC, September 1996).

Notes: Dollars = current dollars. Price index = chained-type price index, 1992 = 100. Expenditures cover most, but not all, pollution abatement and control activities, which are defined as those resulting from rules, policies and conventions, and formal regulations restricting the release of pollutants into common-property media such as the air and water. Solid waste management includes the collection and disposal of solid waste and the alteration of production processes that generate less solid waste. Other consists of the value of reclaimed materials and energy that can not be assigned to a specific media category. This series was discontinued after 1994.

Table 2.4 U.S. Pollution Abatement Expenditures by Sector, 1972-1994

Year	Personal consumption		Business		Government	
	billion dollars	*price index*	*billion dollars*	*price index*	*billion dollars*	*price index*
1972	1.35	32.3	10.69	30.9	3.41	32.0
1973	1.86	34.4	12.20	34.1	3.86	34.7
1974	2.33	43.0	14.59	40.1	4.93	39.5
1975	3.25	46.2	16.41	44.0	6.89	41.1
1976	3.81	48.6	18.38	46.4	7.62	43.8
1977	4.34	51.3	21.04	49.6	7.41	46.8
1978	4.85	54.3	23.40	53.3	8.65	51.0
1979	5.52	65.5	26.97	59.7	9.94	56.9
1980	6.65	79.8	29.93	67.4	11.11	61.6
1981	8.20	86.5	32.51	74.7	10.98	67.4
1982	8.36	86.6	33.54	78.4	11.09	70.4
1983	9.76	86.9	35.02	80.9	11.45	74.1
1984	11.04	88.0	39.36	83.7	12.86	76.9
1985	12.16	90.1	42.04	85.6	14.54	80.9
1986	12.68	86.4	44.11	85.3	16.11	82.7
1987	11.34	89.5	46.73	87.0	18.54	84.7
1988	12.48	91.2	48.40	89.5	19.67	88.1
1989	11.09	94.0	52.23	93.2	21.77	91.1
1990	9.33	96.2	58.30	96.6	23.99	94.5
1991	7.43	97.5	61.09	98.6	25.23	97.9
1992	7.90	100.0	65.93	100.0	26.64	100.0
1993	8.47	102.5	69.01	102.7	28.30	102.5
1994	9.76	106.0	76.63	106.2	31.23	105.5

Source: Vogan, C.R., "Pollution Abatement and Control Expenditures, 1972-94," *Survey of Current Business* (GPO, Washington, DC, September 1996).

Notes: Dollars = current dollars. Price index = chained-type price index, 1992 = 100. Expenditures are attributed to the sector that performs the air or water pollution abatement or solid waste collection and disposal. Personal consumption refers to expenditures to purchase and operate motor vehicle emission abatement devices. Government refers to pollution abatement expenditures by federal, state, and local governments and government enterprise fixed capital for publicly owned electric utilities and public sewer systems. This series was discontinued after 1994.

Table 2.5 U.S. Pollution Abatement Expenditures by Industry, 1973-1994

	Chemicals and allied products								
	Capital expenditures				Operating costs				
Year	Air	Water	Solid waste	Total	Air	Water	Solid waste	Total	Cost offsets
	millions of current dollars								
1973	164.4	214.6	16.8	395.9	174.1	247.6	80.2	502.3	83.1
1974	250.6	264.4	24.1	539.2	203.8	335.6	104.0	643.3	104.5
1975	359.5	387.7	35.0	780.2	249.9	430.9	126.7	807.4	140.7
1976	319.8	577.4	44.7	942.0	295.6	514.7	173.2	983.5	188.7
1977	339.9	593.1	49.6	982.5	335.5	685.2	217.6	1,238.3	206.4
1978	376.3	385.9	65.1	827.5	398.8	794.1	280.1	1,473.0	231.3
1979	314.6	360.7	95.6	770.9	485.3	895.2	287.0	1,667.5	230.4
1980	325.9	350.0	104.8	780.7	539.9	942.9	368.8	1,851.8	305.9
1981	335.0	322.2	95.6	752.8	571.7	1,069.1	406.9	2,047.8	341.1
1982	272.8	256.5	98.3	627.6	556.1	1,112.3	438.2	2,106.5	345.2
1983	159.0	187.4	49.0	395.4	624.9	1,106.0	467.4	2,198.2	297.4
1984	142.9	212.4	32.7	418.1	622.0	1,206.3	517.1	2,345.4	357.5
1985	193.7	271.5	272.5	738.1	672.9	1,267.7	599.4	2,540.0	268.6
1986	197.8	325.5	101.0	624.4	646.5	1,301.8	705.9	2,654.3	336.4
1988	370.7	487.8	236.5	1,095.0	706.4	1,428.5	940.1	3,074.9	443.8
1989	380.3	598.6	215.9	1,194.8	794.0	1,613.8	1,101.4	3,509.2	395.9
1990	596.2	995.0	260.9	1,852.1	841.9	1,799.0	1,302.5	3,943.4	405.7
1991	816.4	942.3	307.5	2,066.1	879.6	1,786.9	1,380.5	4,046.9	353.7
1992	774.5	1,017.3	329.1	2,120.9	1,026.9	1,946.8	1,451.3	4,425.1	511.2
1993	767.5	937.9	252.5	1,957.9	1,013.6	1,957.0	1,377.6	4,348.2	362.1
1994	676.9	1,005.6	248.4	1,931.0	1,138.7	1,996.7	1,431.5	4,566.9	321.0
	Petroleum and coal products								
1973	222.5	96.1	3.2	321.8	192.5	125.4	19.9	337.8	44.3
1974	341.3	119.7	1.3	462.3	238.3	153.3	28.5	420.1	83.5
1975	398.2	155.7	1.7	555.7	339.4	192.1	31.7	563.1	137.7
1976	236.5	199.8	5.2	441.4	466.1	263.3	45.3	774.8	183.8
1977	167.7	195.6	5.3	368.5	601.3	289.3	57.4	948.0	238.4
1978	311.2	100.5	7.6	419.3	636.4	304.1	57.0	997.4	261.8
1979	397.8	119.4	17.1	534.3	750.7	370.8	25.3	1,173.8	324.1
1980	402.3	114.2	15.4	531.9	910.1	406.9	101.0	1,418.0	506.7
1981	440.8	131.7	18.2	590.6	1,118.0	437.2	130.2	1,685.5	565.6
1982	533.2	165.7	13.1	712.1	1,195.1	472.0	133.7	1,800.8	335.3
1983	308.2	164.7	12.0	485.0	1,203.6	552.3	137.9	1,893.7	524.9
1984	195.1	96.8	19.8	311.7	1,327.9	583.8	171.1	2,083.5	552.8
1985	175.0	88.4	27.0	290.4	1,278.5	586.5	198.5	2,063.4	500.0
1986	273.6	121.5	29.2	424.3	1,230.9	578.0	196.4	2,005.2	498.2
1988	208.2	203.7	70.8	482.8	1,175.8	561.7	268.0	2,005.5	480.0
1989	146.5	230.4	40.7	417.6	1,258.2	578.7	333.0	2,170.0	523.1
1990	425.7	400.8	90.3	916.8	1,472.2	701.9	530.8	2,704.9	562.0
1991	996.7	373.3	92.5	1,462.5	1,464.7	793.9	590.4	2,849.0	480.5
1992	2,079.8	492.6	112.6	2,685.0	1,428.9	742.8	413.7	2,585.4	475.9
1993	1,974.7	567.2	106.6	2,648.5	1,585.3	685.2	377.4	2,647.9	419.4
1994	1,982.3	406.9	122.9	2,572.0	1,742.0	755.7	417.2	2,914.9	337.8

See next page for continuation of table.

Table 2.5 U.S. Pollution Abatement Expenditures by Industry, 1973-1994 (continued)

	Primary metal industries								
	Capital expenditures				Operating costs				
Year	Air	Water	Solid waste	Total	Air	Water	Solid waste	Total	Cost offsets
	millions of current dollars								
1973	397.2	84.7	16.8	498.6	264.7	148.3	53.8	466.8	51.5
1974	510.5	132.7	12.5	646.8	339.6	181.2	69.5	590.2	76.9
1975	640.6	187.5	5.4	833.5	429.9	209.4	75.9	715.2	95.3
1976	632.5	197.8	3.4	833.7	575.7	229.5	90.7	895.8	100.7
1977	616.0	250.2	8.4	874.6	721.6	268.3	132.3	1,122.3	126.3
1978	563.3	219.1	9.4	791.8	809.6	333.0	178.9	1,321.4	141.7
1979	588.8	227.3	6.9	823.1	981.7	442.0	163.5	1,587.2	241.8
1980	539.7	180.7	19.6	740.0	998.2	463.2	215.3	1,677.3	169.5
1981	567.2	144.1	16.9	728.2	1,111.9	549.2	250.7	1,911.8	189.7
1982	423.1	133.7	13.0	569.8	897.2	448.4	167.6	1,513.6	148.5
1983	147.6	100.2	7.5	225.3	904.3	454.6	256.7	1,615.6	95.4
1984	175.2	72.9	26.0	274.0	1,017.3	450.7	301.7	1,769.7	171.6
1985	142.9	84.3	25.6	252.9	1,067.0	517.4	278.7	1,863.0	136.8
1986	102.8	74.6	48.4	225.9	968.5	509.4	264.1	1,721.9	184.6
1988	167.3	100.6	41.8	309.8	965.8	516.1	327.2	1,809.0	189.8
1989	216.3	138.7	52.1	407.0	883.1	574.3	473.7	1,931.1	190.4
1990	278.6	166.8	53.7	499.1	943.7	565.4	516.4	2,025.5	206.3
1991	499.2	131.9	42.2	673.4	911.7	564.0	526.9	2,002.6	185.1
1992	342.6	123.5	59.5	525.7	933.1	575.0	485.3	1,993.4	164.2
1993	280.7	92.0	69.5	442.2	944.5	598.2	474.6	2,017.2	136.4
1994	290.1	98.5	39.4	428.0	982.1	692.2	537.2	2,211.5	133.8
	Transportation equipment								
1973	52.6	41.7	6.9	101.2	35.2	51.1	43.4	129.8	20.1
1974	52.7	41.5	9.2	103.4	44.8	59.5	50.5	154.8	13.6
1975	32.1	36.4	6.8	75.4	52.2	66.4	49.7	168.3	13.4
1976	21.1	53.6	3.8	78.5	56.9	83.5	57.6	197.9	14.5
1977	36.9	39.4	6.3	82.6	60.6	97.3	76.1	233.9	13.5
1978	71.0	57.9	10.7	139.5	77.3	110.2	93.0	280.5	16.6
1979	120.1	59.5	9.9	189.5	96.4	126.3	109.1	331.8	36.9
1980	201.4	60.7	12.9	275.0	110.7	137.4	153.2	401.5	24.6
1981	209.2	60.0	14.2	283.3	117.5	150.7	157.7	426.1	19.3
1982	59.7	36.5	12.1	108.3	105.6	153.5	137.6	396.5	18.2
1983	33.0	55.0	10.2	98.3	157.5	224.2	178.6	560.3	22.3
1984	71.3	116.9	19.4	207.6	192.9	280.1	212.6	685.6	22.7
1985	254.5	165.1	36.9	456.5	194.5	283.9	260.3	738.8	23.7
1986	432.4	81.8	26.8	541.1	195.7	338.5	304.9	839.0	28.2
1988	87.6	80.4	42.2	210.2	215.7	299.2	459.5	974.4	38.7
1989	156.0	84.6	46.2	286.8	212.2	318.1	470.1	1,000.3	43.1
1990	206.6	142.6	46.1	395.3	247.3	373.1	611.6	1,232.0	41.2
1991	175.8	94.7	30.8	301.4	254.7	319.6	544.0	1,118.3	45.9
1992	179.4	69.2	32.5	281.0	298.5	347.0	526.2	1,171.7	68.7
1993	178.7	67.1	31.8	277.6	302.4	350.9	541.2	1,194.4	64.1
1994	244.8	60.8	31.3	336.9	293.7	342.5	480.2	1,116.4	71.4

See next page for continuation of table.

Table 2.5 U.S. Pollution Abatement Expenditures by Industry, 1973-1994 (continued)

Year	Capital expenditures: Air	Capital expenditures: Water	Capital expenditures: Solid waste	Capital expenditures: Total	Operating costs: Air	Operating costs: Water	Operating costs: Solid waste	Operating costs: Total	Cost offsets
	millions of current dollars								
Food and kindred products									
1973	77.6	104.8	14.3	196.7	39.1	110.4	53.6	203.1	32.6
1974	73.4	111.7	14.3	199.2	48.8	143.5	76.8	268.9	52.2
1975	75.6	93.9	11.4	180.9	53.2	153.7	87.7	294.2	62.6
1976	102.5	97.6	7.4	207.5	57.7	187.5	100.5	345.9	63.7
1977	67.9	103.6	12.5	183.9	56.2	211.6	89.5	357.1	53.3
1978	67.7	94.4	12.9	175.0	69.4	243.2	99.4	412.0	57.1
1979	57.9	111.1	13.6	182.7	91.0	297.9	115.3	504.2	80.3
1980	61.7	133.0	13.5	208.2	81.6	314.3	123.6	519.4	79.5
1981	53.9	104.8	14.8	173.5	78.3	343.3	157.5	579.1	91.2
1982	47.4	110.9	11.0	169.3	77.1	328.1	116.2	522.1	51.1
1983	37.7	105.1	10.9	153.8	96.1	402.3	151.3	649.6	32.7
1984	50.6	91.8	12.2	154.5	101.3	458.1	155.0	714.4	43.7
1985	66.2	77.4	11.7	155.1	106.3	525.2	201.0	832.1	33.4
1986	61.9	108.2	15.7	185.8	126.0	559.9	246.1	932.1	w/h
1988	100.2	91.0	19.8	211.0	157.8	673.3	328.9	1,160.0	110.6
1989	51.7	183.6	25.2	260.6	137.4	663.5	255.3	1,056.2	82.0
1990	64.6	163.3	21.1	249.0	145.9	692.4	270.4	1,108.8	87.0
1991	94.6	359.5	27.7	481.8	149.6	788.5	316.1	1,254.2	71.6
1992	85.1	202.6	29.1	316.8	162.7	835.7	313.6	1,312.0	82.2
1993	73.9	113.6	32.4	219.9	156.1	857.8	325.4	1,339.3	65.1
1994	105.9	152.8	15.5	274.3	172.4	940.5	334.7	1,447.6	91.5
Paper and allied products									
1973	166.4	161.0	12.1	339.6	59.2	118.1	43.2	220.5	54.6
1974	270.8	193.2	12.9	476.9	81.2	152.0	55.7	289.0	84.8
1975	323.0	266.0	16.3	605.3	100.9	185.5	57.5	344.0	112.2
1976	180.6	278.6	27.3	486.6	123.3	239.1	67.3	430.3	137.6
1977	134.1	261.7	31.6	427.4	133.5	309.0	86.4	529.0	150.8
1978	123.9	189.0	28.7	341.6	158.4	357.6	105.6	622.0	175.6
1979	207.0	180.6	38.8	426.4	176.6	400.5	121.1	698.2	161.5
1980	197.4	111.2	31.0	339.6	196.2	436.7	129.1	762.1	248.1
1981	168.0	86.5	31.1	285.5	211.8	469.9	148.0	829.7	298.5
1982	190.0	93.7	29.7	313.4	206.7	455.2	134.1	796.0	213.7
1983	122.3	65.9	27.9	216.1	226.5	508.9	183.6	919.1	255.3
1984	151.9	68.2	42.1	262.3	280.7	566.1	213.2	1,060.1	118.4
1985	190.9	106.0	35.6	332.4	313.0	573.4	234.4	1,120.8	107.3
1986	137.1	96.9	37.3	271.3	319.2	565.7	269.7	1,154.6	133.8
1988	233.4	97.2	87.1	417.7	372.4	627.7	343.2	1,343.3	245.6
1989	392.4	261.0	154.9	808.2	388.1	686.8	374.2	1,449.0	264.9
1990	414.0	509.6	151.7	1,075.2	397.5	788.3	421.0	1,606.8	266.4
1991	480.8	552.7	199.0	1,232.6	400.8	790.7	443.5	1,635.0	170.4
1992	396.7	373.4	234.5	1,004.6	535.6	822.7	502.4	1,860.7	254.6
1993	307.3	289.2	119.2	715.6	511.2	852.7	537.5	1,901.5	234.0
1994	241.9	195.9	198.1	635.9	536.9	829.5	513.1	1,879.5	285.1

See next page for continuation of table.

Table 2.5 U.S. Pollution Abatement Expenditures by Industry,1973-1994 (continued)

	Rubber and miscellaneous plastic products								
	Capital expenditures				Operating costs				
Year	Air	Water	Solid waste	Total	Air	Water	Solid waste	Total	Cost offsets
	millions of current dollars								
1973	13.5	7.3	3.3	24.2	12.2	10.1	20.4	42.6	4.6
1974	22.2	13.5	2.2	37.9	15.7	15.1	28.2	58.8	19.5
1975	22.2	6.6	3.1	31.9	20.7	18.4	25.7	64.8	12.5
1976	24.2	10.0	3.1	37.4	22.3	24.0	34.0	80.3	15.8
1977	17.4	13.8	5.4	36.6	19.8	18.9	35.1	73.8	7.7
1978	18.7	5.5	3.4	27.7	17.7	23.9	43.3	84.9	8.0
1979	12.9	9.3	2.9	25.1	32.2	29.6	49.9	111.7	13.6
1980	12.6	6.9	2.3	21.7	30.4	27.6	50.2	108.2	18.1
1981	15.3	5.9	6.5	21.8	29.8	29.4	58.8	118.3	14.0
1982	14.8	7.7	2.7	25.2	22.2	28.2	39.8	90.2	7.0
1983	12.0	3.8	7.8	23.6	50.9	52.8	62.0	165.8	6.6
1984	20.5	7.0	5.8	33.4	51.1	48.7	68.1	168.0	9.9
1985	21.3	3.2	5.2	29.7	46.7	55.6	90.8	193.1	10.0
1986	20.1	9.7	6.2	36.0	50.9	52.0	123.3	226.2	15.1
1988	21.7	11.3	7.8	40.7	62.5	62.2	153.3	277.9	18.7
1989	50.3	16.0	12.0	78.2	85.3	99.6	218.4	403.3	25.6
1990	68.9	11.0	13.9	93.8	96.6	113.4	217.6	427.6	24.3
1991	50.8	18.8	12.2	81.7	121.0	76.9	243.0	440.9	29.4
1992	71.1	18.2	7.3	96.7	105.7	73.3	200.5	379.6	26.7
1993	44.0	11.6	7.6	63.3	104.6	83.5	197.1	385.2	24.9
1994	52.4	17.2	5.6	75.2	119.2	90.7	229.8	439.6	35.5

Source: U.S. Department of Commerce, Bureau of the Census, *Pollution Abatement Costs and Expenditures*, Current Industrial Reports (GPO, Washington, DC, annual).

Notes: Data for 1987 not available. w/h = withheld by industry. Data are for selected industries. Does not include all industries covered in the survey. This series was discontinued after 1994.

Table 2.6 Employment and Revenues in U.S. Environmental Industries, 1980 to 1996

Industry	Employment 1980	Employment 1990	Employment 1996	Revenues 1980	Revenues 1990	Revenues 1996
	thousands			*billions of dollars*		
Analytical services[1]	6.0	20.2	16.5	0.4	1.5	1.5
Water treatment works[2]	53.9	95.0	120.9	9.2	19.8	26.6
Solid waste management[3]	83.2	209.5	234.6	8.5	26.1	33.8
Hazardous waste management[4]	6.8	56.9	51.2	0.6	6.3	6.0
Remediation/industrial services	6.9	107.2	95.3	0.4	8.5	8.6
Consulting & engineering	20.5	144.2	159.7	1.5	12.5	15.6
Water equipment & chemicals	62.4	97.9	123.3	6.3	13.5	17.4
Instrument manufacturing	2.5	18.8	26.6	0.2	2.0	3.2
Air pollution control equipment[5]	28.3	82.7	82.6	3.0	10.7	11.8
Waste management equipment[6]	41.9	88.8	94.9	4.0	10.4	12.1
Process & prevention technology	2.1	8.9	20.3	0.1	0.4	0.9
Water utilities[7]	76.9	104.7	122.2	11.9	19.8	26.3
Resource recovery[8]	48.7	118.4	131.3	4.4	13.1	16.3
Environmental energy sources[9]	22.4	21.1	26.7	1.5	1.8	2.4
Total[10]	462.5	1,174.3	1,306.1	52.0	146.4	184.3

Source: Environmental Business International, Inc., *Environmental Business Journal*, (Environmental Business International, Inc., San Diego, CA, monthly).

Notes: [1]Covers environmental laboratory testing and services. [2]Mostly revenues collected by municipal entities. [3]Covers activities such as collection, transportation, transfer stations, disposal, landfill ownership, and management for solid waste. [4]Transportation and disposal of hazardous, medical, and nuclear waste. [5]Includes stationary and mobile sources. [6]Includes vehicles, containers, liners, processing, and remedial equipment. [7]Revenues generated from the sale year. [8]Revenues generated from the sale of recovered metals, paper, plastic, etc. [9]Includes solar, geothermal, and conservation devices. [10]Covers approximately 59,000 private and public companies engaged in environmental activities.

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256

Public Lands and Recreation

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258

Table 3.1 Lands Under the Control of Selected Federal Agencies, 1970-1996

Year	National Park System	National Wildlife Refuge System	National Forest System	Bureau of Reclamation	Bureau of Land Management
			million acres		
1970	29.6	30.7	182.6	9.4	451.1
1971	29.9	30.9	182.6	8.2	451.0
1972	30.4	31.1	182.8	8.3	450.9
1973	30.5	31.1	183.0	8.2	450.8
1974	31.1	33.9	182.1	8.2	447.3
1975	31.0	34.1	183.3	8.0	447.3
1976	31.3	34.4	183.4	7.3	446.8
1977	31.3	34.5	183.5	7.3	427.2
1978	76.7	34.6	183.6	7.1	457.4
1979	76.7	46.8	183.2	7.1	397.5
1980	77.0	71.9	183.1	7.2	343.0
1981	79.1	88.8	186.4	7.1	343.4
1982	79.4	88.8	186.6	7.1	341.1
1983	79.4	88.9	186.5	7.0	342.3
1984	79.4	90.2	186.4	7.9	341.9
1985	79.5	90.4	186.3	7.8	337.1
1986	79.5	90.5	186.5	9.0	334.1
1987	79.6	90.6	186.5	8.5	333.6
1988	80.0	90.8	186.3	8.8	270.4
1989	80.1	91.3	186.9	8.6	269.6
1990	80.2	90.6	187.1	9.0	272.0
1991	80.3	90.8	187.0	8.6	269.0
1992	80.7	91.0	187.1	8.6	268.5
1993	80.3	91.5	187.2	8.6	267.6
1994	83.3	91.8	187.3	8.6	267.1
1995	83.2	92.3	187.2	8.6	264.3
1996	83.2	92.6	187.3	8.6	264.3

Sources: U.S. Department of Agriculture, Forest Service, *Land Areas of the National Forest System* (USDA, FS, Washington, DC, annual).

U.S. Department of the Interior, Fish and Wildlife Service, *Lands Under the Control of the U.S. Fish and Wildlife Service* (DOI, FWS, Washington, DC, annual).

U.S. Department of the Interior, National Park Service, *Areas Administered by the National Park Service: Information Tables* (DOI, NPS, Washington, DC, annual).

U.S. Department of the Interior, Bureau of Land Management, *Public Land Statistics* (DOI, BLM, Washington, DC, annual).

U.S. Department of the Interior, Bureau of Reclamation, unpublished, Denver, CO, 1994.

Notes: na = not available. Data reflect year-end cumulative totals. National Park Service data for 1978-1996 are not directly comparable with data for earlier years due to reclassification of several sites within the system.

Table 3.2 National Wilderness Preservation System and National Wild and Scenic River System, 1968-1996

Year	National Wilderness Preservation System million acres	National Wild and Scenic River System river miles
1968	10.03	773
1969	10.19	773
1970	10.40	868
1971	10.40	868
1972	11.03	895
1973	11.03	961
1974	11.38	1,018
1975	12.72	1,145
1976	14.45	1,610
1977	14.45	1,610
1978	19.00	2,299
1979	19.00	2,299
1980	79.71	5,662
1981	79.84	6,908
1982	79.88	6,908
1983	80.21	6,908
1984	88.55	7,217
1985	88.70	7,224
1986	88.80	7,363
1987	88.99	7,709
1988	90.81	9,264
1989	91.46	9,281
1990	94.97	9,318
1991	95.03	9,463
1992	95.39	10,295
1993	95.44	10,516
1994	103.72	10,734
1995	103.60	10,734
1996	103.60	10,815

Sources: U.S. Department of Agriculture, Forest Service, National Wilderness Preservation System Fact Sheet, unpublished, Washington, DC, annual.

U.S. Department of the Interior, National Park Service, River Mileage Classifications for Components of the National Wild and Scenic River System, unpublished, Washington, DC, annual.

Notes: na = not available. Data reflect year-end cumulative totals.

Table 3.3 National Estuarine Research Reserves and National Marine Sanctuaries, 1975-1996

Year	Estuarine Research Reserves		Marine Sanctuaries	
	number	acres	number	sq. nmi.
1975	1	4,700	2	101.0
1976	3	14,205	2	101.0
1977	3	14,205	2	101.0
1978	4	22,605	2	101.0
1979	5	216,363	2	101.0
1980	9	223,426	3	1,353.0
1981	11	229,652	6	2,323.3
1982	14	240,571	6	2,323.3
1984	15	242,121	6	2,323.3
1986	16	245,149	7	2,323.6
1987	16	245,149	7	2,323.6
1988	17	247,348	7	2,323.6
1989	18	253,477	8	2,720.7
1990	18	259,945	9	5,415.3
1991	19	399,302	9	5,415.3
1992	21	400,559	13	11,419.3
1993	22	401,570	13	11,419.3
1994	22	433,864	14	11,419.3
1995	22	433,865	14	11,419.3
1996	21[1]	427,528	14	11,419.3

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Office of Ocean and Coastal Resources Management, Sanctuaries and Reserves Division, unpublished, Washington, DC, 1996.

Notes: sq. nmi. = square nautical miles. [1]The Waimanu, Hawaii National Estuarine Research Reserve (NERR) site was withdrawn from the NERR System on May 1, 1996.

Table 3.4 National Register of Historic Places, 1967-1996

Year	Properties listed	Properties removed	Year	Properties listed	Properties removed
	number			number	
1967	873	2	1982	29,999	420
1968	903	3	1983	35,112	434
1969	1,106	4	1984	39,121	440
1970	1,888	19	1985	42,538	445
1971	3,026	51	1986	45,936	452
1972	4,376	93	1987	48,254	525
1973	6,646	144	1988	51,286	574
1974	8,247	188	1989	53,838	635
1975	10,805	231	1990	56,688	651
1976	12,561	265	1991	58,209	683
1977	14,203	290	1992	60,500	716
1978	16,575	338	1993	62,095	749
1979	20,589	366	1994	63,710	792
1980	24,680	403	1995	65,255	810
1981	26,499	406	1996	66,805	833

Source: U.S. Department of the Interior, National Park Service, The National Register of Historic Places, unpublished, Washington, DC, 1996.

Note: Data are year-end cumulative totals.

Table 3.5 Recreational Fishing and Hunting in the United States, 1955-1996

Year	Fishermen: Fresh-water	Fishermen: Salt-water	Fishermen: Total	Hunters: Small game	Hunters: Big game	Hunters: Water-fowl	Hunters: Total	Total sports-men
	millions							
1955	18.42	4.56	20.81	9.82	4.41	1.99	11.78	24.92
1960	21.68	6.29	25.32	12.11	6.28	1.96	14.64	30.44
1965	[illegible]	8.31	28.34	10.58	6.57	1.65	13.58	32.88
1970	29.36	9.46	33.15	11.67	7.77	2.89	14.34	36.28
1975	36.60	13.74	41.29	14.18	11.04	4.28	17.09	45.77
1980	35.78	11.97	41.87	12.50	11.05	3.18	16.76	46.97
1985	39.12	12.89	45.35	11.13	12.58	3.20	16.34	49.83
1991	31.04	8.89	39.98	7.64	10.75	3.01	14.06	39.98
1966	29.73	9.44	39.69	6.93	11.27	3.04	13.98	39.69

Year	Fishing days: Fresh-water	Fishing days: Salt-water	Fishing days: Total	Hunting days: Small game	Hunting days: Big game	Hunting days: Water-fowl	Hunting days: Total	Total sporting days
	millions							
1955	338.83	58.62	397.45	118.63	30.83	19.96	169.42	566.87
1960	385.17	80.60	465.77	138.19	39.19	15.16	192.54	658.31
1965	426.92	95.84	522.76	128.45	43.85	13.53	185.82	708.58
1970	592.49	113.69	706.19	124.04	54.54	25.11	203.69	909.88
1975	890.58	167.50	1,050.08	269.65	100.60	31.22	401.48	1,459.55
1980	788.39	164.04	952.42	225.79	117.41	26.18	348.54	1,300.98
1985	895.03	171.06	1,064.99	214.54	135.45	25.93	350.39	1,415.38
1991	439.54	74.70	511.24	77.13	128.41	22.24	227.78	761.33
1996	513.74	103.03	623.54	75.02	153.72	26.50	255.56	879.10

Sources: U.S. Department of the Interior, Fish and Wildlife Service, *National Survey of Fishing, Hunting, and Wildlife-Associated Recreation* (DOI, FWS, Washington, DC, 1993).

—, *1996 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation: National Overview* (DOI, FWS, Washington, DC, 1997).

Notes: Number of fishermen and hunters includes persons 16 years and older. Total number of hunters includes 1,411 hunters of other animals in 1991 and 1,472 in 1996. Totals may not agree with sum of components due to independent rounding and because of multiple responses (e.g., where sportsmen participate in more than one activity per outing). The survey methodology used in 1996 was similar to that used for the 1991 survey so the estimates are comparable. However, these estimates are not strictly comparable with estimates from previous years.

Table 3.6 U.S. Marine Recreational Fisheries by Region, 1981-1996

Year	North Atlantic			Mid-Atlantic			South Atlantic		
	Fishing trips (number in millions)	Fish caught (number in millions)	Fish weight (million pounds)	Fishing trips (number in millions)	Fish caught (number in millions)	Fish weight (million pounds)	Fishing trips (number in millions)	Fish caught (number in millions)	Fish weight (million pounds)
1981	5.76	36.98	68.79	14.01	100.82	118.56	8.55	44.48	37.87
1982	7.04	46.75	85.71	15.50	81.15	105.42	13.63	64.15	48.53
1983	7.10	35.20	68.38	16.57	125.02	124.65	14.46	62.99	65.20
1984	5.32	24.58	39.63	15.76	101.11	100.53	15.09	59.77	50.05
1985	7.07	41.08	59.43	14.74	90.85	79.40	15.32	67.18	59.96
1986	7.48	49.89	81.97	18.84	153.94	135.53	14.90	59.42	53.56
1987	5.78	34.29	55.17	14.72	99.92	116.72	16.95	56.30	51.56
1988	5.74	25.72	39.73	14.90	77.90	85.89	18.82	56.08	54.85
1989	5.23	24.58	33.10	12.17	64.58	76.97	16.36	46.05	46.35
1990	5.54	18.65	28.89	13.35	84.59	56.60	13.57	40.78	35.77
1991	6.80	26.69	35.63	15.98	126.00	65.19	17.39	54.95	47.66
1992	5.70	17.74	21.17	12.22	75.03	47.33	16.74	54.09	45.00
1993	6.23	20.99	24.30	15.29	97.57	55.08	16.80	50.89	37.35
1994	6.28	25.88	23.92	16.24	94.95	45.86	19.93	72.17	50.09
1995	6.51	21.98	19.79	15.58	88.52	58.87	18.75	65.24	50.44
1966	6.76	23.43	21.29	16.50	86.42	55.74	16.82	51.26	43.76

Year	Gulf of Mexico			Total Atlantic & Gulf			Pacific		
	Fishing trips (number in millions)	Fish caught (number in millions)	Fish weight (million pounds)	Fishing trips (number in millions)	Fish caught (number in millions)	Fish weight (million pounds)	Fishing trips (number in millions)	Fish caught (number in millions)	Fish weight (million pounds)
1981	12.06	87.39	53.00	40.38	289.67	278.22	11.00	51.00	na
1982	13.42	113.33	75.70	49.59	305.38	315.36	11.00	53.00	na
1983	19.98	146.17	80.92	60.11	369.38	339.15	11.00	44.52	na
1984	19.64	133.87	71.75	55.81	319.33	261.97	10.00	46.84	na
1985	15.42	101.20	65.45	52.55	300.30	264.23	9.90	43.18	na
1986	19.04	144.08	96.56	60.26	407.32	367.62	11.03	55.31	na
1987	16.09	101.56	66.54	53.54	286.08	289.98	9.97	47.54	na
1988	19.74	130.95	70.85	59.20	290.65	251.31	12.42	51.22	na
1989	15.62	113.91	66.90	48.38	249.11	223.32	9.45	41.29	na
1990	13.31	106.38	51.55	45.77	250.40	173.00	na	na	na
1991	18.17	177.34	79.77	58.34	284.98	228.24	na	na	na
1992	18.08	145.03	68.93	52.74	291.88	182.40	na	na	na
1993	17.43	147.33	68.52	54.75	316.78	185.24	6.89	30.92	20.94
1994	17.50	148.86	63.57	59.95	341.85	183.44	7.19	27.17	17.92
1995	17.12	135.78	73.06	57.96	311.53	202.16	7.22	27.61	24.31
1996	16.32	118.63	64.57	56.40	279.73	185.35	7.85	34.05	22.96

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, *Fisheries of the United States 1996* (GPO: Washington, DC, 1997).

Notes: na = not available. Gulf of Mexico totals do not include Texas. No data are available for the Pacific Coast for 1990, 1991, and 1992. The 1993-1996 estimates for the Pacific Coast do not include Washington State data. Data for 1996 are preliminary.

Table 3.7 Visits to Selected U.S. Federal Recreation Areas, 1977-1996

Year	National Parks	National Wildlife Refuges	Bureau of Reclamation Recreation Areas	National Forests	Army Corps of Engineers Reservoirs	Bureau of Land Management Lands
	million visits	*million visitors*		*million visitor days*		
1977	211	27	55	205	424	na
1978	222	26	63	219	439	na
1979	205	25	59	220	449	na
1980	198	23	60	234	457	na
1981	210	26	69	236	469	64
1982	214	24	63	233	480	40
1983	217	22	66	228	480	42
1984	218	23	76	228	482	34
1985	216	24	76	225	502	31
1986	237	25	80	237	506	36
1987	246	25	80	239	181	64
1988	250	26	82	242	191	57
1989	256	26	84	253	191	50
1990	263	27	80	263	190	70
1991	268	28	80	279	192	68
1992	275	28	83	287	203	65
1993	273	28	84	296	200	39
1994	269	27	na	330	205	40
1995	270	28	na	345	206	73
1996	266	30	na	341	212	73

Sources: U.S. Army Corps of Engineers, Directorate of Civil Works, Operations, Construction and Readiness Division, Natural Resources Management Branch, Visitation to Corps Recreation Areas, unpublished, Washington, DC, 1997.

U.S Department of Agriculture, Forest Service, *Report of the Forest Service* (USDA, FS, Washington, DC, annual).

U.S. Department of the Interior, Bureau of Land Management, *Public Land Statistics* (DOI, BLM, Washington, DC, annual).

U.S. Department of the Interior, Bureau of Reclamation, Utilization of Recreation Areas on Reclamation Projects, unpublished, Denver, CO, 1994.

U.S. Department of the Interior, Fish and Wildlife Service, Refuge Division, Refuge Management Information System, unpublished, Washington, DC, 1997.

U.S. Department of the Interior, National Park Service, Statistical Office, *National Park Statistical Abstract*, (DOI, NPS, Denver, CO, annual).

Notes: Visitor day = 12 hours. Data for Army Corps of Engineers refer to recreation days of use for years 1977 through 1986 and 12-hour visitor days thereafter.

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Ecosystems and Biodiversity

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Table 4.1 Trends in Selected U.S. Resident and Neotropical Migrant Bird Species, 1966-1996, 1966-1979, and 1980-1996

	Resident/short distance migrant bird species		
Common name	Long-term trend (1966-1996)	Mid-term trend (1966-1979)	Short-term trend (1980-1996)
	% change per year		
Northern bobwhite	- 2.5	- 1.0	- 3.3
Mourning dove	- 0.3	1.2	- 0.8
Great horned owl	1.1	3.0	- 0.8
Red-headed woodpecker	- 2.2	0.7	- 4.7
Downy woodpecker	- 0.5	0.1	- 1.3
Hairy woodpecker	0.1	1.7	- 0.1
Pileated woodpecker	1.1	1.1	0.8
Red-cockaded woodpecker	- 2.0	8.8	- 8.8
Horned lark	- 1.2	- 0.4	- 1.8
Blue jay	- 1.6	- 1.1	- 1.3
Black-capped chickadee	1.5	1.6	0.1
Carolina chickadee	- 0.9	- 0.8	- 1.7
Tufted titmouse	1.0	- 1.9	2.4
Brown-headed nuthatch	- 2.2	- 2.0	- 2.4
Brown creeper	- 1.5	- 2.6	- 0.9
Carolina wren	0.8	0.0	2.1
Marsh wren	3.9	- 3.1	6.7
Brown thrasher	- 1.1	- 0.9	- 1.1
American robin	0.9	0.7	0.8
Eastern bluebird	2.4	- 4.9	3.9
Northern mockingbird	- 0.9	- 2.0	0.3
Northern cardinal	0.0	- 0.8	0.9
Song sparrow	- 0.1	- 1.9	1.0
Field sparrow	- 3.3	- 5.6	- 2.2
White-throated sparrow	- 1.0	- 2.2	- 0.4
Slate-colored junco	0.0	- 0.5	0.3

	Neotropical migrant bird species		
Common name	Long-term trend (1966-1996)	Mid-term trend (1966-1979)	Short-term trend (1980-1996)
	% change per year		
Yellow-billed cuckoo	- 1.6	3.2	- 3.1
Chuck-will's-widow	- 1.5	- 1.0	- 0.8
Whip-poor-will	- 1.1	- 1.9	- 0.9
Ruby-throated hummingbird	1.5	1.3	2.1
Eastern wood pewee	- 1.6	- 2.1	- 1.2
Least flycatcher	- 1.5	- 2.3	- 0.6
Olive-sided flycatcher	- 4.1	- 2.3	- 3.9
Yellow-bellied flycatcher	0.8	2.7	4.9
Great-crested flycatcher	- 0.1	0.6	0.3

See next page for continuation of table

Table 4.1 Trends in Selected U.S. Resident and Neotropical Migrant Bird Species, 1966-1996, 1966-1979, and 1980-1996 (continued)

Common name	Neotropical migrant bird species Long-term trend (1966-1996)	Mid-term trend (1966-1979)	Short-term trend (1980-1996)
	% change per year		
Purple martin	- 0.1	3.1	- 2.0
Barn swallow	1.0	4.2	- 1.6
Blue-gray gnatcatcher	1.0	0.8	2.2
Veery	- 1.1	0.8	- 1.6
Wood thrush	- 1.7	0.5	- 1.2
Gray catbird	- 0.2	0.5	0.2
White-eyed vireo	- 0.1	0.2	0.2
Red-eyed vireo	1.1	2.2	1.6
Solitary vireo	3.0	3.4	3.6
Golden-winged warbler	- 2.5	- 3.2	2.1
Tennessee warbler	6.5	8.5	6.5
Northern parula	0.2	0.2	0.2
Cape May warbler	0.9	14.8	- 10.4
Blue-winged warbler	0.5	1.3	0.7
Prairie warbler	- 2.6	- 5.2	- 0.9
Cerulean warbler	- 3.8	- 5.7	- 0.4
Blackpoll warbler	- 3.1	9.6	- 1.8
Chestnut-sided warbler	- 0.3	0.2	0.6
Wilson's warbler	- 0.3	- 1.9	- 2.0
Nashville warbler	0.6	- 2.8	0.7
Kentucky warbler	- 1.0	0.2	- 1.4
American redstart	- 0.5	- 1.2	0.4
Prothonotary warbler	- 1.6	1.0	- 2.2
Ovenbird	1.4	0.7	2.0
Northern waterthrush	0.8	4.7	- 0.5
Louisiana waterthrush	0.3	0.5	- 1.2
Common yellowthroat	- 0.2	0.7	- 0.6
Yellow-breasted chat	- 0.3	- 3.5	1.0
Scarlet tanager	0.1	3.3	- 0.4
Summer tanager	- 0.2	0.2	- 0.5
Baltimore oriole	- 0.4	2.0	- 1.4
Orchard oriole	- 1.8	- 2.6	- 1.0
Rose-breasted grosbeak	0.1	3.3	- 1.3
Indigo bunting	- 0.7	0.1	- 1.0
Grasshopper sparrow	- 3.5	- 4.6	- 1.8
Chipping sparrow	0.0	- 2.1	0.5

Source: Sauer, J.R., J.E. Hines, G. Gough, I. Thomas and B.G. Peterjohn, *The North American Breeding Bird Survey Results and Analysis. Version 96.4* (U.S. Department of the Interior, Patuxent Wildlife Research Center, Laurel, MD, 1997).

Table 4.2 North American Duck Population Estimates, 1955-1996

Year	Northern pintail	Mallard	Canvasback	Redhead	Gadwall	Green wing teal	Blue wing teal	Scaup	Am. widgeon	No. shoveler	Black duck (Atlan)	Black duck (Miss)
						millions						
1955	9.78	8.78	0.59	0.54	0.65	1.81	5.31	5.62	3.32	1.64	0.58	0.18
1956	10.37	10.45	0.70	0.76	0.77	1.53	5.00	5.99	3.15	1.78	0.42	0.21
1957	6.61	9.30	0.63	0.51	0.67	1.10	4.30	5.77	2.92	1.48	0.42	0.23
1958	6.04	11.23	0.75	0.46	0.50	1.35	5.46	5.35	2.55	1.38	0.28	0.26
1959	5.87	9.02	0.49	0.50	0.59	2.65	5.10	7.04	3.79	1.58	0.31	0.18
1960	5.72	7.37	0.61	0.50	0.78	1.43	4.29	4.87	2.99	1.82	0.34	0.17
1961	4.22	7.33	0.44	0.32	0.66	1.73	3.66	5.38	3.05	1.38	0.32	0.16
1962	3.62	5.54	0.36	0.51	0.91	0.72	3.01	5.29	1.96	1.27	0.34	0.11
1963	3.85	6.75	0.51	0.41	1.06	1.24	3.72	5.44	1.83	1.40	0.33	0.14
1964	3.29	6.06	0.64	0.53	0.87	1.56	4.02	5.13	2.59	1.72	0.37	0.22
1965	3.59	5.13	0.52	0.60	1.26	1.28	3.60	4.64	2.30	1.42	0.33	0.16
1966	4.81	6.73	0.66	0.71	1.68	1.62	3.73	4.44	2.32	2.15	0.30	0.15
1967	5.28	7.51	0.50	0.74	1.39	1.59	4.49	4.93	2.33	2.32	0.29	0.21
1968	3.49	7.09	0.56	0.50	1.95	1.43	3.46	4.41	2.30	1.69	0.34	0.14
1969	5.90	7.53	0.50	0.63	1.57	1.49	4.14	5.14	2.94	2.16	0.33	0.15
1970	6.39	9.99	0.58	0.62	1.61	2.18	4.86	5.66	3.47	2.23	0.28	0.14
1971	5.85	9.42	0.45	0.53	1.61	1.89	4.61	5.14	3.27	2.01	0.26	0.13
1972	6.98	9.27	0.43	0.55	1.62	1.95	4.28	8.00	3.20	2.47	0.27	0.14
1973	4.36	8.08	0.62	0.50	1.25	1.95	3.33	6.26	2.88	1.62	0.27	0.15
1974	6.60	6.88	0.51	0.63	1.59	1.87	4.98	5.78	2.67	2.01	0.25	0.08
1975	5.90	7.73	0.60	0.83	1.64	1.67	5.89	6.46	2.78	1.98	0.24	0.12
1976	5.48	7.93	0.61	0.67	1.25	1.55	4.75	5.82	2.51	1.75	0.28	0.15
1977	3.93	7.40	0.66	0.63	1.30	1.29	4.46	6.26	2.58	1.45	0.26	0.10
1978	5.11	7.43	0.37	0.73	1.56	2.17	4.50	5.98	3.28	1.98	0.27	0.09
1979	5.38	7.88	0.58	0.70	1.76	2.07	4.88	7.66	3.11	2.41	0.24	0.08
1980	4.51	7.71	0.74	0.73	1.39	2.05	4.90	6.38	3.60	1.91	0.20	0.08
1981	3.48	6.41	0.62	0.60	1.40	1.91	3.72	5.99	2.95	2.33	0.24	0.08
1982	3.71	6.41	0.51	0.62	1.63	1.54	3.66	5.53	2.46	2.15	0.24	0.07
1983	3.51	6.46	0.53	0.72	1.52	1.88	3.37	7.17	2.64	1.88	0.20	0.09
1984	2.97	5.42	0.53	0.67	1.52	1.41	3.98	7.02	3.02	1.62	0.23	0.06
1985	2.52	4.96	0.38	0.58	1.30	1.48	3.50	5.10	2.05	1.70	0.22	0.06
1986	2.74	6.12	0.44	0.56	1.55	1.68	4.48	5.24	1.74	2.13	0.23	0.10
1987	2.63	5.79	0.45	0.50	1.31	2.01	3.53	4.86	2.01	1.95	0.20	0.07
1988	2.01	6.37	0.44	0.44	1.35	2.06	4.01	4.67	2.21	1.68	0.23	0.11
1989	2.11	5.65	0.48	0.51	1.42	1.84	3.13	4.34	1.97	1.54	0.24	0.07
1990	2.26	5.45	0.54	0.48	1.67	1.79	2.78	4.29	1.86	1.76	0.23	0.01
1991	1.80	5.45	0.49	0.45	1.58	1.56	3.76	5.26	2.25	1.72	0.23	0.05
1992	2.10	5.98	0.48	0.60	2.03	1.77	4.33	4.64	2.21	1.95	0.20	0.08
1993	2.05	5.71	0.47	0.49	1.76	1.70	3.19	4.08	2.05	2.05	0.21	0.08
1994	2.97	6.98	0.53	0.65	2.32	2.11	4.62	4.53	2.38	2.91	0.22	0.08
1995	2.76	8.27	0.77	0.89	2.84	2.30	5.14	4.45	2.62	2.86	0.22	0.09
1996	2.74	7.94	0.85	0.83	2.98	2.50	6.41	4.22	2.27	3.45	na	na

Source: U.S. Department of the Interior, Fish and Wildlife Service, Office of Migratory Bird Management in Conjunction with the Canadian Wildlife Service. *Status of Waterfowl and Fall Flight Forecast* (DOI, FWS, Washington, DC, annual).

Notes: Am. = American. No. = Northern. Atlan = Atlantic Flyway. Miss = Mississippi River Flyway.

Table 4.3 North American Goose and Swan Population Estimates, 1970-1996

Year	Canada goose	Snow goose	Greater white-fronted goose	Brant	Tundra swan Eastern	Tundra swan Western
	millions		thousands			
1970	0.295	0.908	50.6	141.7	55	31
1971	0.432	1.191	39.3	300.2	58	99
1972	0.611	1.467	45.8	197.8	63	83
1973	0.702	1.168	43.0	166.0	57	34
1974	0.593	1.355	43.2	218.7	64	70
1975	0.593	1.251	40.4	211.4	67	54
1976	0.876	1.764	53.4	249.0	79	51
1977	0.789	1.341	50.4	221.0	76	47
1978	0.784	2.454	53.1	208.9	70	46
1979	0.690	1.486	49.3	173.4	79	54
1980	0.696	1.872	132.1	215.4	64	65
1981	1.035	1.615	161.0	291.2	93	84
1982	1.143	2.007	182.1	227.0	73	91
1983	1.179	1.974	153.7	233.3	87	67
1984	0.971	1.768	183.2	260.4	81	62
1985	1.167	2.282	181.5	290.8	94	49
1986	1.108	1.818	172.4	246.2	91	66
1987	1.379	2.805	178.6	219.9	95	53
1988	1.541	1.797	207.3	278.0	77	59
1989	2.735	2.394	278.0	273.2	91	79
1990	2.906	2.131	322.1	287.0	90	40
1991	2.595	2.596	376.5	279.4	97	49
1992	3.523	2.544	409.4	302.5	110	64
1993	3.172	2.207	330.1	225.0	76	62
1994	3.703	3.647	1,125.7	287.2	84	79
1995	4.220	3.484	1,186.5	281.9	81	53
1996	4.037	3.076	1,552.0	232.8	79	98

Source: U.S. Department of the Interior, Fish and Wildlife Service, Office of Migratory Bird Management in Conjunction with the Canadian Wildlife Service, *Status of Waterfowl and Fall Flight Forecast* (DOI, FWS, Washington, DC, annual).

Notes: Data for Canada goose are aggregate population totals for 13 separate populations that nest in North America. Data for snow goose are aggregate population totals for the greater snow goose, lesser snow goose, and Ross' goose populations. The 1995 survey of the western tundra swan population was incomplete.

Table 4.4 Status of Marine Mammal Stocks in U.S. Waters, 1995

Marine mammals of the Pacific					
Species	Stock area	Nmin	PBR	Total annual mortality	Trend
Pygmy killer whale	Hawaii	na	na	na	U
Pilot whale (short finned)	Hawaii	na	na	na	U
Risso's dolphin	Hawaii	na	na	na	U
Killer whale	Hawaii	na	na	0.0	U
Melon-headed whale	Hawaii	na	na	0.0	U
False killer whale	Hawaii	na	na	na	U
Pantropical spotted dolphin	Hawaii	na	na	na	U
Stripped dolphin	Hawaii	na	na	na	U
Spinner dolphin	Hawaii	677	6.8	1.0	U
Rough-toothed dolphin	Hawaii	na	na	na	U
Bottlenose dolphin	Hawaii	na	na	0.0	U
Pygmy sperm whale	Hawaii	na	na	na	U
Dwarf sperm whale	Hawaii	na	na	0.0	U
Sperm whale	Hawaii	na	na	na	U
Cuvier's beaked whale	Hawaii	na	na	0.0	U
Blainville's beaked whale	Hawaii	na	na	0.0	U
California sea lion	U.S.	84,195	5,052	2,434	I
Harbor seal	California	32,800	1,968	729	I
Harbor seal	WA inland	13,053	783	14	I
Harbor seal	OR/WA	28,322	850	233	I
Northern elephant seal	CA breeding	42,000	1,743	166	I
Northern fur seal	San Miguel Is.	10,536	227	0	I
Guadalupe fur seal	Mexico to CA	3,028	104	0	I
Hawaiian monk seal	Hawaii	1,300	4.6	1	D
NE spotted dolphin	E. Trop. Pacific	648,900	6,489	934	D
W/S offshore spotted dolphin	E. Trop. Pacific	1,145,100	11,451	1,226	S
Eastern spinner dolphin	E. Trop. Pacific	518,500	5,185	743	S
Whitebelly spinner dolphin	E. Trop. Pacific	872,000	8,720	619	S
Common dolphin (northern)	E. Trop. Pacific	3,531,000	3,531	101	S
Common dolphin (central)	E. Trop. Pacific	297,400	2,974	151	S
Common dolphin (southern)	E. Trop. Pacific	1,845,600	18,456	0	S
Stripped dolphin	E. Trop. Pacific	1,745,900	17,459	11	S
Coastal spotted dolphin	E. Trop. Pacific	22,500	225	na	S
Central Am. spinner dolphin	E. Trop. Pacific	na	na	11	S
Sea otter	Central CA	na	na	na	I
Sea otter	WA	na	na	na	I

See next page for continuation of table.

Table 4.4 Status of Marine Mammal Stocks in U.S. Waters, 1995 (continued)

Marine Mammals of the Atlantic and Gulf of Mexico

Species	Stock area	Nmin	PBR	Total annual mortality	Trend
No. Atlantic right whale	W. No. Atlantic	395	0.4	2.5	I
Humpback whale	W. No. Atlantic	4,848	9.7	1	U
Fin whale	W. No. Atlantic	1,704	3.4	na	U
Sei whale	W. No. Atlantic	155	0.3	0.3	U
Minke whale	E. Coast Canada	2,053	21.0	2.5	U
Blue whale	W. No. Atlantic	na	na	0.0	U
Sperm whale	W. No. Atlantic	226	0.5	1.6	U
Dwarf sperm whale	W. No. Atlantic	na	na	na	U
Pygmy sperm whale	W. No. Atlantic	na	na	na	U
Killer whale	W. No. Atlantic	na	na	0	U
Pygmy killer whale	W. No. Atlantic	6	0.1	0	U
Northern bottlenose whale	W. No. Atlantic	na	na	0	U
Cuvier's beaked whale	W. No. Atlantic	na	na	34	U
True's beaked whale	W. No. Atlantic	na	na	34	U
Gervais beaked whale	W. No. Atlantic	na	na	34	U
Blainville's beaked whale	W. No. Atlantic	na	na	34	U
Sowerby's beaked whale	W. No. Atlantic	na	na	34	U
Risso's dolphin	W. No. Atlantic	11,140	111	68	U
Pilot whale (long-finned)	W. No. Atlantic	3,537	28	109	U
Pilot . hale (short-finned)	W. No. Atlantic	457	3.7	109	U
Atlantic white-sided dolphin	W. No. Atlantic	12,538	125	127	U
White-beaked dolphin	W. No. Atlantic	na	na	0.0	U
Common dolphin	W. No. Atlantic	3,233	32	449	U
Atlantic spotted dolphin	W. No. Atlantic	4,885	9.8	31	U
Pantropical spotted dolphin	W. No. Atlantic	na	na	31	U
Stripped dolphin	W. No. Atlantic	9,165	73	63	U
Spinner dolphin	W. No. Atlantic	na	na	1.0	U
Bottlenose dolphin	Mid-Atl. offshore	9,195	92	128	U
Bottlenose dolphin	Mid-Atl. coastal	2,482	25	29	S
Harbor porpoise	Gulf of Maine*	40,279	403	1,876	U
Harbor seal	W. No. Atlantic	28,810	1,729	476	I
Gray seal	N. W. No. Atlantic	2,035	122	4.5	I
Harp seal	N. W. No. Atlantic	na	na	0	I
Hooded seal	N. W. No. Atlantic	na	na	0	I
Sperm whale	N. Gulf of Mexico	411	0.8	0	U
Bryde's whale	N. Gulf of Mexico	17	0.2	0	U
Cuvier's beaked whale	N. Gulf of Mexico	20	0.2	0	U
Blainsville's beaked whale	N. Gulf of Mexico	na	na	0	U
Gervais' beaked whale	N. Gulf of Mexico	na	na	0	U
Bottlenose dolphin	G. of Mexico OCS	43,233	432	5	U
Bottlenose dolphin	G. of Mexico S&S	4,530	45	5	U
Bottlenose dolphin	W. G. of Mexico coast	2,938	29	13	U
Bottlenose dolphin	E. G. of Mexico coast	8,963	90	8	U
Bottlenose dolphin	G. of Mexico inland**	na	39.7	30	U

See next page for continuation of table

Table 4.4 Status of Marine Mammal Stocks in U.S. Waters, 1995 (continued)

Marine Mammals of the Atlantic and Gulf of Mexico

Species	Stock area	Nmin	PBR	Total annual mortality	Trend
Atlantic spotted dolphin	N. Gulf of Mexico	2,555	23	1.5	U
Pantropical spotted dolphin	N. Gulf of Mexico	26,510	265	1.5	U
Stripped dolphin	N. Gulf of Mexico	3,409	34	0	U
Spinner dolphin	N. Gulf of Mexico	4,465	45	0	U
Rough-toothed dolphin	N. Gulf of Mexico	660	6.6	0	U
Clymene dolphin	N. Gulf of Mexico	4,120	41	0	U
Fraser's dolphin	N. Gulf of Mexico	66	0.7	0	U
Killer whale	N. Gulf of Mexico	197	2	0	U
False killer whale	N. Gulf of Mexico	236	2.4	0	U
Pygmy killer whale	N. Gulf of Mexico	285	2.8	0	U
Dwarf sperm whale	N. Gulf of Mexico	na	na	0	U
Pygmy sperm whale	N. Gulf of Mexico	na	na	0	U
Melon-headed whale	N. Gulf of Mexico	2,888	29	0	U
Risso's dolphin	N. Gulf of Mexico	2,199	22	19	U
Pilot whale (short finned)	N. Gulf of Mexico	186	1.9	0.3	U
West Indian manatee	Florida	na	na	na	D
West Indian manatee	Antillean	na	na	na	D

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, *Our Living Oceans, Report on the Status of U.S. Living Marine Resources, 1995*, NOAA Technical Memorandum NMFS-F/SPO-19 (DOC, NOAA, NMFS, Washington, DC, 1996).

Notes: N_{min} = minimum population. PBR = potential biological removal. Trend is increasing (I), decreasing (D), stable (S), and unknown (U). na = not available. *Also includes the Bay of Fundy. **Represents at least 33 individually recognized stocks of bottlenose dolphin in U.S. Gulf of Mexico bays, sounds, and other estuaries. OCS = Outer Continental Shelf. S&S = Shelf and Slope. Three species of marine mammals in the Pacific have Endangered Species Act status: sperm whale (endangered), Guadalupe fur seal (threatened), and Hawaiian monk seal (endangered). Two species of marine mammals in the Pacific have Marine Mammal Protection Act status: northeastern spotted dolphin (depleted) and eastern spinner dolphin (depleted). Nine species of marine mammals in the Atlantic and Gulf of Mexico have Endangered Species Act status: North Atlantic right whale (endangered), humpback whale (endangered), fin whale (endangered), sei whale (endangered), blue whale (endangered), W. North Atlantic sperm whale (endangered), Gulf of Mexico sperm whale (endangered), Florida West Indian manatee (endangered), and Antillean West Indian manatee (endangered). One marine mammal species in the Atlantic and Gulf of Mexico has Marine Mammal Protection Act status: Mid-Atlantic coastal bottlenose dolphin (depleted).

Table 4.5 Status of Sea Turtle Stocks in U.S. Waters, 1995

Region Species (ESA status)	Historic level	Current level	Current trend
	number of nesting females		
Atlantic			
Loggerhead (T)	Unknown	20,000 to 26,000[1]	Stable[2]
Green (T,E[3])	Unknown	600 to 800[1]	Increasing
Kemp's ridley (E)	40,000	700 to 800[4]	Stable[2]
Leatherback (E)	Unknown	Unknown	Unknown
Hawksbill (E)	Unknown	Unknown	Declining
Pacific			
Loggerhead (T)	Unknown	Unknown	Declining
Green (T)	15,000	500[5]	Increasing[6]
Olive ridley (T)	Unknown	Unknown	Unknown
Leatherback (E)	Unknown	Unknown	Unknown
Hawksbill (E)	Unknown	>75[7]	Unknown

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, *Our Living Oceans. Report on the Status of U.S. Living Marine Resources, 1995*, NOAA Technical Memorandum NMFS-F/SPO-19 (DOC, NOAA, NMFS, Washington, DC, 1996).

Notes: ESA = Endangered Species Act. [1]Based on estimate using 2.5 nests per female. [2]Stable, but critically low. [3]Listed as endangered in Florida, threatened in the U.S. Atlantic and Pacific. [4]Based on estimate using 1.5 nests per female. Kemp's ridley turtles nest only on one Mexican beach. [5]Historic level for Hawaii only. Estimated 1995 total adult female population is 1,500 in Hawaii, 100-300 in American Samoa; current level in Guam is unknown. [6]Trend in Hawaii only, monitored at French Frigate Shoals; however, great concern exists over increasing frequency of fibropapilloma disease in all Hawaiian green turtles. [7]Estimated total adult population in Hawaii; average number of female hawksbill turtles nesting annually in Hawaii is about 15. Current abundance in Guam and American Samoa is unknown.

Table 4.6 U.S. Threatened and Endangered Species, 1980-1996

	Threatened animal species by taxonomic group										Threatened plant species	Total
	Mammals	Birds	Reptiles	Amphibians	Fish	Crustaceans	Snails	Insects	Arachnids	Clams		
					number of species							
1980	4	3	12	3	14	0	5	7	0	0	9	57
1981	4	3	12	3	14	0	5	6	0	0	10	57
1982	4	3	12	3	14	1	5	6	0	0	10	58
1983	4	3	12	3	15	1	5	6	0	0	11	60
1984	5	3	12	3	18	1	5	5	0	0	11	63
1985	5	4	12	3	24	1	5	5	0	0	25	84
1986	6	4	14	3	28	1	5	7	0	0	27	95
1987	6	9	17	4	32	1	5	7	0	0	35	116
1988	6	9	17	4	31	1	5	7	0	0	48	128
1989	7	9	17	5	32	1	6	7	0	0	51	135
1990	8	11	17	5	33	2	6	9	0	2	61	154
1991	8	11	17	5	34	2	6	9	0	2	64	159
1992	9	12	18	5	36	2	7	9	0	2	74	174
1993	9	16	19	5	37	2	7	9	0	3	80	187
1994	9	16	19	5	39	3	7	9	0	3	90	200
1995	9	16	19	5	39	3	7	9	0	6	93	206
1996	9	16	19	6	40	3	7	9	0	6	101	216

	Endangered animal species by taxonomic group										Endangered plant species	Total
	Mammals	Birds	Reptiles	Amphibians	Fish	Crustaceans	Snails	Insects	Arachnids	Clams		
					number of species							
1980	32	58	13	5	33	1	2	7	0	23	50	223
1981	32	58	13	5	33	1	3	7	0	23	51	225
1982	32	58	14	5	35	2	3	7	0	23	57	235
1983	35	53	14	5	34	3	3	7	0	23	58	234
1984	37	66	14	5	33	3	3	8	0	22	71	261
1985	43	68	14	5	40	3	3	8	0	23	93	299
1986	43	71	14	5	42	4	3	8	0	23	114	326
1987	46	73	15	5	42	5	3	8	0	28	139	362
1988	50	72	15	5	46	8	3	11	4	31	153	397
1989	51	72	15	6	50	8	3	12	4	34	166	420
1990	53	72	15	6	53	8	3	12	4	37	179	441
1991	56	72	15	6	54	8	7	14	4	40	238	513
1992	56	72	15	6	55	9	11	16	4	40	295	578
1993	56	72	14	6	61	11	12	17	4	50	323	626
1994	57	74	14	7	66	14	15	19	4	51	420	741
1995	57	75	14	7	66	14	15	20	5	51	432	756
1996	57	74	14	7	67	14	15	20	5	51	513	837

Source: U.S. Department of the Interior, Fish and Wildlife Service, Division of Endangered Species.

Notes: Grizzly bear, gray wolf, bald eagle, piping plover, roseate tern, green sea turtle, and olive ridley sea turtle are listed both as threatened and endangered. Data are cumulative year-end totals.

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Air Quality and Climate

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Table 5.1 U.S. Emissions of Carbon Monoxide by Source, Ten-Year Intervals, 1940-1980, and Annually, 1985-1996

	Fuel combustion				Transportation			Miscellaneous	
Year	Electric utilities	Industrial	Other	Total	On-road vehicles	Non-road engines & vehicles	Total	Forest wildfires	Other
					million tons				
1940	0.004	0.435	14.890	15.329	30.121	8.051	38.172	25.130	na
1950	0.110	0.549	10.656	11.315	45.196	11.610	56.806	11.159	3.976
1960	0.110	0.661	6.250	7.021	64.266	11.575	75.841	4.487	6.523
1970	0.237	0.770	3.625	4.632	88.034	11.287	99.321	5.620	2.289
1980	0.322	0.750	6.230	7.302	78.049	13.758	91.807	5.396	2.948
1985	0.295	0.670	7.525	8.490	77.387	14.626	92.013	2.957	4.970
1986	0.296	0.650	6.607	7.553	73.347	15.184	88.531	2.271	5.015
1987	0.307	0.649	6.011	6.967	71.250	14.959	86.209	3.795	5.057
1988	0.320	0.669	6.390	7.379	71.081	15.780	86.861	10.709	5.186
1989	0.327	0.672	6.450	7.449	66.050	15.781	81.831	3.009	5.144
1990	0.363	0.879	4.269	5.511	57.848	16.117	73.965	5.928	5.280
1991	0.349	0.920	4.587	5.856	62.074	16.040	78.114	3.430	5.321
1992	0.350	0.955	4.849	6.154	59.859	16.374	76.233	1.674	5.378
1993	0.363	1.043	4.181	5.587	60.202	16.592	76.794	1.586	5.427
1994	0.370	1.041	4.108	5.519	61.833	16.873	78.706	4.114	5.500
1995	0.372	1.056	4.506	5.934	54.106	16.841	70.947	1.469	5.581
1996	0.377	1.072	4.513	5.962	52.944	17.002	69.946	1.469	5.630

	Industrial processes								
Year	Chemical industries	Metals processing	Petroleum industries	Other industries	Solvent utilization	Storage and transport	Waste disposal and recycling	Total	Total all sources
					million tons				
1940	4.190	2.750	0.221	0.114	na	na	3.630	10.905	93.615
1950	5.844	2.910	2.651	0.231	na	na	4.717	16.353	102.609
1960	3.982	2.866	3.086	0.342	na	na	5.597	15.873	109.745
1970	3.397	3.644	2.179	0.620	na	na	7.059	16.899	128.761
1980	2.151	2.246	1.723	0.830	na	na	2.300	9.250	116.702
1985	1.845	2.223	0.462	0.694	0.002	0.049	1.941	7.216	115.644
1986	1.853	2.079	0.451	0.715	0.002	0.051	1.916	7.067	110.437
1987	1.798	1.984	0.455	0.713	0.002	0.050	1.850	6.851	108.879
1988	1.917	2.101	0.441	0.711	0.002	0.056	1.806	7.034	117.169
1989	1.925	2.132	0.436	0.716	0.002	0.055	1.747	7.013	104.447
1990	1.183	2.640	0.333	0.537	0.005	0.076	1.079	5.853	96.535
1991	1.127	2.571	0.345	0.548	0.005	0.028	1.116	5.740	98.461
1992	1.112	2.496	0.371	0.544	0.005	0.017	1.138	5.683	95.123
1993	1.093	2.536	0.371	0.594	0.005	0.051	1.248	5.898	95.291
1994	1.171	2.475	0.338	0.600	0.005	0.024	1.225	5.838	99.677
1995	1.223	2.380	0.348	0.624	0.006	0.025	1.185	5.791	89.721
1996	1.223	2.378	0.348	0.635	0.006	0.025	1.203	5.818	88.822

Note: See Table 5.6 for Source.

Table 5.2 U.S. Emissions of Nitrogen Oxides by Source, Ten-Year Intervals, 1940-1980, and Annually, 1985-1996

	Fuel combustion				Transportation			Miscellaneous	
Year	Electric utilities	Industrial	Other	Total	On-road vehicles	Non-road engines & vehicles	Total	Forest wildfires	Other
					million tons				
1940	0.660	2.543	0.529	3.732	1.330	0.991	2.321	na	0.990
1950	1.316	3.192	0.647	5.155	2.143	1.538	3.681	na	0.665
1960	2.536	4.075	0.760	7.371	3.982	1.443	5.425	na	0.441
1970	4.900	4.325	0.836	10.061	7.390	2.642	10.032	na	0.330
1980	7.024	3.555	0.741	11.318	8.621	4.017	12.638	na	0.248
1985	6.127	3.209	0.712	10.048	8.089	4.150	12.239	na	0.310
1986	6.111	3.065	0.694	9.870	7.773	4.555	12.328	na	0.259
1987	6.246	3.063	0.706	10.015	7.651	3.947	11.598	na	0.352
1988	6.545	3.187	0.740	10.472	7.661	4.806	12.467	na	0.727
1989	6.593	3.209	0.736	10.538	7.682	4.693	12.375	na	0.293
1990	6.663	3.035	1.196	10.894	7.040	4.593	11.633	na	0.371
1991	6.519	2.979	1.281	10.779	7.373	4.518	11.891	na	0.286
1992	6.504	3.071	1.353	10.928	7.440	4.658	12.098	na	0.254
1993	6.651	3.151	1.308	11.110	7.510	4.776	12.286	na	0.225
1994	6.565	3.147	1.303	11.015	7.672	4.944	12.616	na	0.383
1995	6.384	3.144	1.298	10.826	7.323	4.675	11.998	na	0.237
1996	6.034	3.170	1.289	10.493	7.171	4.610	11.781	na	0.239

	Industrial processes								
Year	Chemical industries	Metals processing	Petroleum industries	Other industries	Solvent utilization	Storage and transport	Waste disposal and recycling	Total	Total all sources
					million tons				
1940	0.006	0.004	0.105	0.107	na	na	0.110	0.332	7.374
1950	0.063	0.110	0.110	0.093	na	na	0.215	0.591	10.093
1960	0.110	0.110	0.220	0.131	na	na	0.331	0.902	14.140
1970	0.271	0.077	0.240	0.187	na	na	0.440	1.215	21.639
1980	0.216	0.065	0.072	0.205	na	na	0.111	0.669	24.875
1985	0.262	0.087	0.124	0.327	0.002	0.002	0.087	0.891	23.488
1986	0.264	0.080	0.109	0.328	0.003	0.002	0.087	0.872	23.329
1987	0.255	0.075	0.101	0.320	0.003	0.002	0.085	0.841	22.806
1988	0.274	0.082	0.100	0.315	0.003	0.002	0.085	0.860	24.526
1989	0.273	0.083	0.097	0.311	0.003	0.002	0.084	0.852	24.057
1990	0.168	0.097	0.153	0.378	0.001	0.003	0.091	0.891	23.792
1991	0.165	0.076	0.121	0.352	0.002	0.006	0.095	0.817	23.772
1992	0.163	0.081	0.148	0.361	0.003	0.005	0.096	0.857	24.137
1993	0.155	0.083	0.123	0.370	0.003	0.005	0.123	0.862	24.482
1994	0.160	0.091	0.117	0.389	0.003	0.005	0.114	0.879	24.892
1995	0.158	0.098	0.110	0.399	0.003	0.006	0.099	0.873	23.935
1996	0.159	0.098	0.110	0.403	0.003	0.006	0.100	0.879	23.393

Note: See Table 5.6 for Source.

Table 5.3 U.S. Emissions of Volatile Organic Compounds by Source, Ten-Year Intervals, 1940-1980, and Annually, 1985-1996

Year	Fuel combustion				Transportation			Miscellaneous	
	Electric utilities	Industrial	Other	Total	On-road vehicles	Non-road engines & vehicles	Total	Forest wildfires	Other
	million tons								
1940	0.002	0.108	1.867	1.977	4.817	0.778	5.595	3.420	0.659
1950	0.009	0.098	1.336	1.443	7.251	1.213	8.464	1.510	1.020
1960	0.009	0.106	0.768	0.883	10.506	1.215	11.721	0.768	0.805
1970	0.030	0.150	0.541	0.694	12.972	1.713	14.685	0.770	0.331
1980	0.045	0.157	0.848	1.050	8.979	2.142	11.121	0.739	0.395
1985	0.033	0.134	1.403	1.570	9.376	2.240	11.616	0.283	0.283
1986	0.034	0.133	1.230	1.397	8.874	2.342	11.216	0.259	0.288
1987	0.035	0.131	1.117	1.283	8.477	2.244	10.721	0.361	0.294
1988	0.037	0.136	1.188	1.361	8.290	2.432	10.722	0.918	0.312
1989	0.038	0.134	1.200	1.372	7.192	2.422	9.614	0.335	0.307
1990	0.047	0.182	0.776	1.005	6.313	2.502	8.815	0.749	0.401
1991	0.044	0.196	0.835	1.075	6.499	2.503	9.002	0.439	0.392
1992	0.044	0.187	0.884	1.115	6.072	2.551	8.623	0.164	0.401
1993	0.045	0.186	0.762	0.993	6.103	2.581	8.684	0.212	0.415
1994	0.045	0.196	0.748	0.989	6.401	2.619	9.020	0.379	0.405
1995	0.044	0.206	0.823	1.073	5.701	2.433	8.134	0.171	0.415
1996	0.045	0.208	0.822	1.075	5.502	2.426	7.928	0.171	0.416

Year	Industrial processes								
	Chemical industries	Metals processing	Petroleum industries	Other industries	Solvent utilization	Storage and transport	Waste disposal and recycling	Total	Total all sources
	million tons								
1940	0.884	0.325	0.571	0.130	1.971	0.639	0.990	5.510	17.161
1950	1.324	0.442	0.548	0.184	3.679	1.218	1.104	8.499	20.936
1960	0.991	0.342	1.034	0.202	4.403	1.762	1.546	10.280	24.459
1970	1.341	0.394	1.194	0.270	7.174	1.954	1.984	14.311	30.817
1980	1.595	0.273	1.440	0.237	6.584	1.975	0.758	12.861	26.167
1985	0.881	0.076	0.703	0.390	5.699	1.747	0.979	10.475	24.227
1986	0.916	0.073	0.666	0.395	5.626	1.673	0.971	10.320	23.480
1987	0.923	0.070	0.655	0.394	5.743	1.801	0.950	10.536	23.193
1988	0.982	0.074	0.645	0.408	5.945	1.842	0.959	10.855	24.167
1989	0.980	0.074	0.639	0.403	5.964	1.753	0.941	10.754	22.383
1990	0.634	0.122	0.612	0.401	5.750	1.495	0.986	10.000	20.985
1991	0.710	0.123	0.640	0.391	5.782	1.532	0.999	10.177	21.100
1992	0.715	0.124	0.632	0.414	5.901	1.583	1.010	10.379	20.695
1993	0.701	0.124	0.649	0.442	6.016	1.600	1.046	10.578	20.895
1994	0.691	0.126	0.647	0.438	6.162	1.629	1.046	10.739	21.546
1995	0.660	0.125	0.642	0.450	6.183	1.652	1.067	10.779	20.586
1996	0.436	0.070	0.517	0.439	6.273	1.312	0.433	9.480	19.086

Note: See Table 5.6 for Source.

Table 5.4 U.S. Emissions of Sulfur Dioxide by Source, Ten-Year Intervals, 1940-1980, and Annually, 1985-1996

	Fuel combustion				Transportation			Miscellaneous	
Year	Electric utilities	Industrial	Other	Total	On-road vehicles	Non-road engines & vehicles	Total	Forest wildfires	Other
					million tons				
1940	2.427	6.060	3.642	12.129	0.003	3.190	3.193	n/a	0.545
1950	4.515	5.725	3.964	14.204	0.103	2.392	2.495	n/a	0.545
1960	9.264	3.864	2.319	15.447	0.114	0.321	0.435	n/a	0.554
1970	17.398	4.568	1.490	23.456	0.411	0.083	0.494	n/a	0.110
1980	17.469	2.951	0.971	21.391	0.521	0.175	0.696	n/a	0.011
1985	16.273	3.169	0.579	20.021	0.522	0.208	0.730	n/a	0.011
1986	15.804	3.116	0.611	19.531	0.527	0.221	0.748	n/a	0.009
1987	15.819	3.068	0.662	19.549	0.538	0.233	0.771	n/a	0.013
1988	16.110	3.111	0.660	19.881	0.553	0.253	0.806	n/a	0.027
1989	16.340	3.086	0.624	20.050	0.570	0.267	0.837	n/a	0.011
1990	15.909	3.550	0.831	20.290	0.542	0.392	0.934	n/a	0.012
1991	15.784	3.256	0.755	19.795	0.570	0.399	0.969	n/a	0.011
1992	15.416	3.292	0.784	19.492	0.578	0.402	0.980	n/a	0.010
1993	15.189	3.284	0.772	19.245	0.517	0.385	0.902	n/a	0.009
1994	14.889	3.218	0.780	18.887	0.301	0.384	0.685	n/a	0.015
1995	12.080	3.357	0.793	16.230	0.304	0.372	0.676	n/a	0.009
1996	12.604	3.399	0.782	16.785	0.307	0.368	0.675	n/a	0.009

	Industrial processes								
Year	Chemical industries	Metals processing	Petroleum industries	Other industries	Solvent utilization	Storage and transport	Waste disposal and recycling	Total	Total all sources
					million tons				
1940	0.215	3.309	0.224	0.334	na	na	0.003	4.085	19.953
1950	0.427	3.747	0.340	0.596	na	na	0.003	5.113	22.358
1960	0.447	3.986	0.676	0.671	na	na	0.010	5.790	22.227
1970	0.591	4.775	0.881	0.846	na	na	0.008	7.100	31.161
1980	0.280	1.842	0.734	0.918	na	na	0.033	3.773	25.905
1985	0.456	1.042	0.505	0.425	0.001	0.004	0.034	2.467	23.230
1986	0.432	0.888	0.469	0.427	0.001	0.004	0.035	2.256	22.544
1987	0.425	0.648	0.445	0.418	0.001	0.004	0.035	1.976	22.308
1988	0.449	0.707	0.443	0.411	0.001	0.005	0.036	2.052	22.767
1989	0.440	0.695	0.429	0.405	0.001	0.005	0.036	2.010	22.907
1990	0.297	0.726	0.430	0.399	0.000	0.007	0.042	1.901	23.136
1991	0.280	0.612	0.378	0.396	0.000	0.010	0.044	1.720	22.496
1992	0.278	0.615	0.416	0.396	0.001	0.009	0.044	1.759	22.240
1993	0.269	0.603	0.383	0.392	0.001	0.005	0.071	1.724	21.879
1994	0.275	0.562	0.379	0.398	0.001	0.002	0.060	1.677	21.262
1995	0.286	0.530	0.369	0.403	0.001	0.002	0.047	1.638	18.552
1996	0.287	0.530	0.368	0.409	0.001	0.002	0.048	1.645	19.113

Note: See Table 5.6 for Source.

Table 5.5 U.S. Emissions of PM-10 Particulates by Source, Ten-Year Intervals, 1940-1980, and Annually, 1985-1996

	Fuel combustion				Transportation				
Year	Electric utilities	Industrial	Other	Total	On-road vehicles	Non-road engines & vehicles	Total	Natural (wind erosion)	Miscellaneous[1]
					million tons				
1940	0.962	0.708	2.338	4.008	0.210	2.480	2.690	na	na
1950	1.467	0.604	1.674	3.745	0.314	1.788	2.102	na	na
1960	2.117	0.331	1.113	3.561	0.554	0.201	0.755	na	na
1970	1.775	0.641	0.455	2.871	0.443	0.369	0.812	na	0.839
1980	0.879	0.679	0.887	2.445	0.397	0.566	0.963	na	0.852
1985	0.282	0.247	1.009	1.538	0.363	0.561	0.924	4.047	37.736
1986	0.287	0.244	0.889	1.420	0.356	0.634	0.990	10.324	37.077
1987	0.284	0.239	0.812	1.335	0.360	0.520	0.880	1.577	37.453
1988	0.279	0.244	0.862	1.385	0.369	0.672	1.041	18.110	39.444
1989	0.274	0.243	0.869	1.386	0.367	0.649	1.016	12.101	37.461
1990	0.295	0.270	0.631	1.196	0.336	0.598	0.934	2.092	24.419
1991	0.257	0.233	0.657	1.147	0.349	0.598	0.947	2.077	24.122
1992	0.257	0.243	0.383	0.883	0.343	0.618	0.961	2.227	23.865
1993	0.279	0.257	0.588	1.124	0.321	0.633	0.954	0.509	24.196
1994	0.273	0.270	0.570	1.113	0.320	0.652	0.972	2.160	25.461
1995	0.268	0.302	0.610	1.180	0.293	0.585	0.878	1.145	22.454
1996	0.282	0.306	0.598	1.186	0.274	0.591	0.865	5.316	22.702

	Industrial processes								
Year	Chemical industries	Metals processing	Petroleum industries	Other industries	Solvent utilization	Storage and transport	Waste disposal and recycling	Total	Total all sources
					million tons				
1940	0.330	1.208	0.366	3.996	na	na	0.392	6.292	15.956
1950	0.455	1.027	0.412	6.954	na	na	0.505	9.353	17.133
1960	0.309	1.026	0.689	7.211	na	na	0.764	9.999	15.558
1970	0.235	1.316	0.286	5.832	na	na	0.999	8.668	13.190
1980	0.148	0.622	0.138	1.846	na	na	0.273	3.027	7.287
1985	0.058	0.220	0.063	0.611	0.002	0.107	0.278	1.339	45.584
1986	0.059	0.203	0.063	0.620	0.002	0.104	0.274	1.325	51.136
1987	0.058	0.194	0.062	0.606	0.002	0.100	0.265	1.287	42.533
1988	0.062	0.208	0.060	0.601	0.002	0.101	0.259	1.293	61.275
1989	0.063	0.211	0.058	0.591	0.002	0.101	0.251	1.277	53.240
1990	0.077	0.214	0.055	0.583	0.004	0.102	0.271	1.306	29.947
1991	0.068	0.251	0.043	0.520	0.005	0.101	0.276	1.264	29.557
1992	0.071	0.250	0.043	0.506	0.005	0.117	0.278	1.270	29.506
1993	0.066	0.181	0.038	0.501	0.006	0.114	0.334	1.240	28.023
1994	0.076	0.184	0.038	0.495	0.006	0.106	0.313	1.218	30.926
1995	0.067	0.212	0.040	0.511	0.006	0.109	0.287	1.232	26.888
1996	0.067	0.211	0.040	0.510	0.006	0.109	0.290	1.233	31.301

Notes: See Table 5.6 for Source. [1]See Table 5.6 for breakdown of miscellaneous sources.

Table 5.6 Miscellaneous Sources of U.S. PM-10 Emissions, 1985-1996

	Miscellaneous PM-10 (detail from Table 5.5)							
	Fugitive dust						Wildfires	
Year	Agriculture and forestry	Unpaved roads	Paved roads	Construction	Wind erosion & other	Total fugitive dust	and other combustion	Total all sources
	million tons							
1985	7.108	11.644	5.080	12.670	0.339	29.734	0.894	37.736
1986	7.183	11.673	5.262	11.825	0.314	29.075	0.819	37.077
1987	7.326	11.110	5.530	12.121	0.377	29.139	0.988	37.453
1988	7.453	12.379	5.900	11.662	0.346	30.287	1.704	39.444
1989	7.320	11.798	5.769	11.269	0.392	29.229	0.912	37.461
1990	5.146	11.234	2.248	4.249	0.337	18.069	1.203	24.419
1991	5.106	11.206	2.399	4.092	0.378	18.076	0.941	24.122
1992	4.909	10.918	2.423	4.460	0.370	18.171	0.785	23.865
1993	4.475	11.430	2.462	4.651	0.410	18.954	0.768	24.196
1994	4.690	11.370	2.538	5.245	0.570	19.722	1.048	25.461
1995	4.661	11.362	2.409	3.654	0.587	17.013	0.778	22.454
1996	4.708	10.303	2.417	3.950	0.539	17.209	0.783	22.702

Source: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, *National Air Quality and Emissions Trends Report, 1996*, Tables A-1 through A-5 (EPA, OAQPS, Research Triangle Park, NC, 1997) and earlier trends reports.

Notes: n/a = not applicable. na = not available. PM-10 refers to particulate matter with a diameter 10 micrometers or less. Totals may not agree with sum of components due to independent rounding.

Table 5.7 U.S. Emissions of Lead by Source, Five-Year Intervals, 1970-1980, and Annually, 1985-1996

	Fuel combustion				Transportation			Miscellaneous	
Year	Electric utilities	Industrial	Other	Total	On-road vehicles	Non-road engines & vehicles	Total	Forest wildfires	Other
					thousand tons				
1970	0.327	0.237	10.052	10.616	171.961	9.737	181.698	n/a	n/a
1975	0.230	0.075	10.042	10.347	130.206	6.130	136.336	n/a	n/a
1980	0.129	0.060	4.111	4.299	60.501	4.205	64.706	n/a	n/a
1985	0.064	0.030	0.421	0.515	18.052	0.921	18.973	n/a	n/a
1986	0.069	0.025	0.422	0.516	10.245	1.030	11.275	n/a	n/a
1987	0.064	0.022	0.425	0.510	3.317	0.850	4.167	n/a	n/a
1988	0.066	0.019	0.426	0.511	2.566	0.885	3.451	n/a	n/a
1989	0.067	0.018	0.420	0.505	0.982	0.820	1.802	n/a	n/a
1990	0.064	0.018	0.418	0.500	0.421	0.776	1.197	n/a	n/a
1991	0.061	0.018	0.416	0.495	0.018	0.574	0.592	n/a	n/a
1992	0.059	0.018	0.414	0.491	0.018	0.565	0.583	n/a	n/a
1993	0.061	0.019	0.415	0.495	0.019	0.529	0.548	n/a	n/a
1994	0.061	0.018	0.415	0.494	0.019	0.525	0.544	n/a	n/a
1995	0.057	0.016	0.414	0.487	0.019	0.545	0.564	n/a	n/a
1996	0.062	0.017	0.414	0.493	0.019	0.545	0.564	n/a	n/a

	Industrial processes								
Year	Chemical industries	Metals processing	Petroleum industries	Other industries	Solvent utilization	Storage and transport	Waste disposal and recycling	Total	Grand total
					thousand tons				
1970	0.103	24.224	n/a	2.028	n/a	n/a	2.200	28.555	220.869
1975	0.120	9.923	n/a	1.337	n/a	n/a	1.595	12.975	159.659
1980	0.104	3.026	n/a	0.808	n/a	n/a	1.210	5.148	74.153
1985	0.118	2.097	n/a	0.316	n/a	n/a	0.871	3.402	22.890
1986	0.108	1.820	n/a	0.199	n/a	n/a	0.844	2.972	14.763
1987	0.123	1.835	n/a	0.202	n/a	n/a	0.844	3.004	7.681
1988	0.136	1.965	n/a	0.172	n/a	n/a	0.817	3.090	7.053
1989	0.136	2.088	n/a	0.173	n/a	n/a	0.765	3.161	5.468
1990	0.136	2.169	n/a	0.169	n/a	n/a	0.804	3.278	4.975
1991	0.132	1.975	n/a	0.167	n/a	n/a	0.807	3.081	4.168
1992	0.093	1.773	n/a	0.056	n/a	n/a	0.812	2.734	3.808
1993	0.092	1.889	n/a	0.054	n/a	n/a	0.824	2.869	3.911
1994	0.096	2.027	n/a	0.053	n/a	n/a	0.829	3.005	4.043
1995	0.144	2.067	n/a	0.059	n/a	n/a	0.622	2.892	3.943
1996	0.117	2.000	n/a	0.057	n/a	n/a	0.638	2.812	3.869

Source: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, *National Air Quality and Emissions Trends Report, 1996*, Table A-6 (EPA, OAQPS, Research Triangle Park, NC, 1997) and earlier trends reports.

Note: n/a = not applicable.

Table 5.8 U.S. Emissions of Greenhouse Gases by Source, 1989-1996

Gas/Source	1989	1990	1991	1992	1993	1994	1995	1996
				million metric tons of carbon				
Carbon dioxide								
Energy use	1,360.9	1,345.8	1,330.6	1,351.5	1,380.9	1,401.3	1,411.4	1,463.0
Adjustments	9.2	9.1	10.7	9.6	10.6	11.4	11.2	10.8
Other sources	18.6	18.8	18.8	18.9	20.1	20.8	22.1	22.1
Total	1,388.7	1,373.7	1,360.2	1,379.9	1,411.6	1,433.5	1,444.6	1,495.9
				million metric tons of gas				
Methane								
Energy sources	11.95	12.07	11.97	11.96	11.08	11.42	11.15	11.57
Waste mgt.	11.04	11.11	11	10.89	10.83	10.73	10.6	10.44
Agriculture	8.18	8.29	8.55	8.77	8.79	9.11	9.05	8.75
Industrial sources	0.12	0.12	0.11	0.12	0.12	0.13	0.13	0.13
Total	31.29	31.59	31.63	31.74	30.82	31.38	30.93	30.90
				thousand metric tons of gas				
Nitrous oxide								
Agriculture	159	164	167	168	176	179	159	146
Energy use	184	188	185	188	186	186	187	189
Industrial sources	100	97	100	96	101	107	108	111
Total	444	449	452	452	463	472	454	446
CFC-11	80	60	5	48	39	37	36	10
CFC-12	114	113	106	97	90	59	52	47
CFC-113	78	50	39	28	20	17	17	16
Halons	0	3	3	3	3	3	3	2
HCFC-22	76	72	82	92	100	105	92	93
HFC-23	5	4	4	4	4	4	4	4
PFCs	3	3	3	3	2	2	3	3
Carbon tetrachloride	0	30	0	26	22	16	5	5
Methyl chloroform	296	316	224	215	122	78	46	26
Sulfur hexafluoride	1	1	1	1	1	1	1	1

Source: U.S. Department of Energy, Energy Information Administration, *Emissions of Greenhouse Gases in the United States, 1996*, DOE/EIA-0573(96) (GPO, Washington, DC, 1997).

Notes: CFC = Chlorofluorocarbon. HCFC = Hydrochlorofluorocarbon. HFC = Hydrofluorocarbon. PFC = Perfluorocarbon. na = not available. Emissions include direct and indirect effects. Other carbon dioxide emissions are from cement production, gas flaring, and other industrial processes.

Table 5.9 U.S. Precipitation Chemistry by Region, 1985–1995

Year	Ph	Hydro-gen ion	Sulfate ion	Nitrate ion	Ammon-ium ion	Calcium ion	Precip-itation
	units	ug/l		milligrams per liter			cm
				Eastern United States			
1985	4.43	37.57	2.02	1.25	0.23	0.15	106.7
1986	4.42	38.16	2.14	1.30	0.24	0.13	102.2
1987	4.42	38.06	2.09	1.33	0.26	0.14	100.7
1988	4.43	37.05	2.14	1.33	0.21	0.17	95.9
1989	4.47	34.25	2.01	1.35	0.31	0.15	110.8
1990	4.49	32.71	1.80	1.18	0.27	0.12	122.6
1991	4.47	34.00	1.87	1.27	0.26	0.14	111.0
1992	4.49	32.04	1.77	1.22	0.25	0.12	108.4
1993	4.47	33.64	1.78	1.28	0.26	0.11	113.7
1994	4.48	33.07	1.71	1.24	0.28	0.13	111.9
1995	4.55	28.17	1.47	1.23	0.28	0.13	109.3
				Western United States			
1985	5.13	7.40	0.82	0.71	0.18	0.23	62.0
1986	5.18	6.57	0.78	0.68	0.17	0.19	72.4
1987	5.11	7.82	0.83	0.83	0.24	0.19	62.2
1988	5.10	7.93	0.93	0.83	0.16	0.27	56.6
1989	5.23	5.84	0.87	0.91	0.29	0.25	56.7
1990	5.21	6.22	0.80	0.87	0.29	0.22	66.2
1991	5.20	6.31	0.77	0.80	0.24	0.21	68.4
1992	5.23	5.86	0.77	0.83	0.28	0.18	65.1
1993	5.27	5.41	0.71	0.76	0.23	0.18	74.4
1994	5.07	8.53	0.76	0.92	0.28	0.20	62.0
1995	5.11	7.73	0.70	0.79	0.27	0.19	77.7
				Entire United States			
1985	4.57	27.07	1.60	1.06	0.21	0.17	91.1
1986	4.57	27.16	1.67	1.08	0.21	0.15	91.8
1987	4.56	27.53	1.65	1.15	0.25	0.15	87.3
1988	4.57	26.91	1.72	1.16	0.19	0.21	82.2
1989	4.61	24.35	1.61	1.20	0.30	0.19	91.9
1990	4.63	23.49	1.45	1.07	0.28	0.16	102.9
1991	4.61	24.36	1.49	1.11	0.26	0.16	96.1
1992	4.64	22.92	1.42	1.00	0.26	0.14	93.3
1993	4.62	23.81	1.41	1.10	0.25	0.14	100.0
1994	4.61	24.53	1.38	1.13	0.28	0.15	94.5
1995	4.68	21.04	1.20	1.08	0.28	0.15	98.3

Source: National Trends Network of the National Atmospheric Deposition Program, unpublished, Fort Collins, CO, 1997.

Notes: ug/l = micrograms per liter. cm = centimeters. Data are from 73 sites in the eastern United States and 39 sites in the western United States. Sites included in the computations are those where (1) precipitation amounts are available for at least 90% of the summary period and (2) at least 60% of the precipitation during the summary period is represented by valid samples.

Table 5.10 U.S. National Composite Mean Ambient Concentrations of Criteria Air Pollutants, 1977-1996

Year	Carbon monoxide ppm	Nitrogen dioxide ppm	Ozone ppm	Lead ug/m3	PM-10 particulates ug/m3	Sulfur dioxide ppm
	(168 sites)	(65 sites)	(238 sites)	(122 sites)	(na)	(278 sites)
1977	10.9	0.026	0.152	1.35	na	0.0133
1978	10.5	0.027	0.156	1.26	na	0.0128
1979	10.1	0.026	0.141	1.06	na	0.0125
1980	9.3	0.024	0.143	0.73	na	0.0112
1981	8.9	0.023	0.131	0.59	na	0.0108
1982	8.2	0.022	0.127	0.50	na	0.0100
1983	8.2	0.022	0.144	0.40	na	0.0097
1984	8.1	0.023	0.128	0.36	na	0.0099
1985	7.3	0.023	0.127	0.25	na	0.0092
1986	7.3	0.022	0.122	0.16	na	0.0091
	(345 sites)	(214 sites)	(600 sites)	(208 sites)	(900 sites)	(479 sites)
1987	6.7	0.021	0.124	0.16	na	0.0089
1988	6.4	0.022	0.133	0.12	32.2	0.0089
1989	6.4	0.021	0.116	0.09	32.0	0.0087
1990	5.9	0.020	0.113	0.09	29.4	0.0081
1991	5.6	0.020	0.114	0.07	29.1	0.0078
1992	5.2	0.019	0.106	0.06	26.8	0.0073
1993	4.9	0.019	0.108	0.05	26.0	0.0071
1994	5.1	0.020	0.108	0.04	26.2	0.0068
1995	4.5	0.019	0.113	0.04	25.1	0.0056
1996	4.2	0.019	0.106	0.04	24.2	0.0056

Source: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, *National Air Quality and Emissions Trends Report, 1996*, Table A-9 (EPA, OAQPS, Research Triangle Park, NC, 1997).

Notes: ppm = parts per million. ug/m3 = micrograms per cubic meter. n/a = not applicable. Sulfur dioxide and nitrogen dioxide records are annual arithmetic means. Carbon monoxide records are arithmetic means of second maximum non-overlapping 8-hour concentrations. Ozone records are arithmetic means of second daily maximum 1-hour concentrations. Lead records are arithmetic means of maximum quarterly measurements. PM-10 records are weighted annual arithmetic means. The National Ambient Air Quality Standards for these pollutants are as follows: sulfur dioxide, 0.03 ppm; carbon monoxide, 9 ppm; ozone, 0.12 ppm; nitrogen dioxide, 0.053 ppm; PM-10, 50 ug/m3; and lead, 1.5 ug/m3.

Table 5.11 Air Quality Trends in Selected U.S. Urban Areas, 1987-1996

PMSA	Trend sites #	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
		number of PSI days greater than 100									
Atlanta	8	27	21	3	17	6	5	17	4	19	6
Baltimore	15	28	43	9	12	20	5	14	17	14	3
Boston	24	5	15	4	1	4	1	3	1	1	0
Chicago	44	17	23	4	3	8	7	1	8	4	3
Cleveland	24	6	21	4	2	3	2	2	4	4	1
Dallas	8	10	14	7	8	1	3	5	1	13	2
Denver	21	37	19	11	9	7	7	3	2	2	1
Detroit	28	9	17	10	3	8	1	2	8	11	3
El Paso	17	32	16	33	27	13	17	10	10	4	9
Houston	28	67	61	41	50	42	30	26	29	54	28
Kansas City	24	6	4	2	2	2	1	2	0	6	3
Los Angeles	36	201	239	226	180	184	185	146	136	103	88
Miami	10	4	5	4	1	2	0	0	0	0	1
Minn/St. Paul	23	14	3	7	3	2	1	0	5	3	1
New York	26	44	46	18	18	22	4	6	8	8	4
Philadelphia	37	35	35	19	14	25	3	21	6	14	5
Phoenix	25	42	27	30	9	4	10	7	9	13	5
Pittsburgh	37	10	20	9	8	4	1	3	2	7	0
San Diego	20	61	84	91	61	40	37	17	16	14	4
San Francisco	9	1	2	1	0	0	0	0	0	1	0
Seattle	14	14	20	8	5	2	1	0	0	0	0
St. Louis	53	17	20	13	8	6	3	6	11	14	4
Wash., DC	34	26	37	8	5	16	2	13	7	8	2
Subtotal	565	713	792	562	455	421	326	304	284	317	173
Other sites	768	852	1,195	738	595	622	386	401	351	408	307
All sites	1,333	1,565	1,987	1,300	1,050	1,043	712	705	635	725	480

Source: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, *National Air Quality and Emissions Trends Report, 1996*, Table A-17 (EPA, OAQPS, Research Triangle Park, NC, 1997).

Notes: PMSA = Primary Metropolitan Statistical Area. PSI = Pollutant Standards Index. Minn = Minneapolis. The PSI index integrates information from many pollutants across an entire monitoring network into a single number which represents the worst daily air quality experienced in an urban area. Only carbon monoxide and ozone monitoring sites with adequate historical data are included in the PSI trend analysis above, except for Pittsburgh, where sulfur dioxide contributes a significant number of days in the PSI high range. PSI index ranges and health effect descriptor words are as follows: 0 to 50 (good); 51 to 100 (moderate); 101 to 199 (unhealthful); 200 to 299 (very unhealthful); and 300 and above (hazardous). The table above shows the number of days when the PSI was greater than 100 (= unhealthful or worse).

Table 5.12 Number of People Living in U.S. Counties with Air Quality Concentrations Above the Level of the National Ambient Air Quality Standards, 1985-1996

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
							millions					
SO_2	2.2	0.9	1.6	1.7	0.1	1.4	5.2	0.0	1.4	0.04	0.0	0.2
NO_2	7.5	7.5	7.5	8.3	8.5	8.5	8.9	0.0	0.0	0.0	0.0	0.0
CO	39.6	41.4	29.4	29.5	33.6	21.7	19.9	14.3	11.6	15.3	12.0	12.7
O_3	76.4	75.0	88.6	111.9	66.7	62.9	69.7	44.6	51.3	50.2	70.8	39.3
Pb	4.5	4.5	1.7	1.6	1.6	5.3	14.7	4.7	5.5	4.4	4.8	4.1
PM-10	na	41.7	21.5	25.6	27.4	18.8	21.5	25.8	9.4	13.1	24.4	7.3
Any NAAQS	na	na	101.8	121.3	84.4	47.4	86.4	53.6	59.1	62.0	79.8	46.6

Source: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, *National Air Quality and Emissions Trends Report, 1996*, Figure 1-2, p. 3 (EPA, OAQPS, Research Triangle Park, NC, 1997) and earlier trends reports.

Notes: NAAQS = National Ambient Air Quality Standards. PM-10 = Particulate matter with a diameter of 10 micrometers or less.

Table 5.13 Population in U.S. Nonattainment Areas Not Meeting at Least One of the National Ambient Air Quality Standards, 1991-1996

	1991	1992	1993	1994	1995	1996
			1990 population in millions			
Population	150.53	148.86	147.07	145.28	132.48	122.75

Source: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, *National Air Quality and Emissions Trends Report, 1996* (EPA, OAQPS, Research Triangle Park, NC, 1997) and earlier trends reports.

Aquatic Resources

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Table 6.1 U.S. Annual Average Precipitation Trends, 1895-1996

Year	Mean	Index	Trend	Year	Mean	Index	Trend	Year	Mean	Index	Trend
	inches	*standardized z-score*			*inches*	*standardized z-score*			*inches*	*standardized z-score*	
1895	26.73	-1.04	-0.53	1929	29.51	-0.10	-0.44	1963	24.77	-1.59	-0.60
1896	28.73	-0.13	-0.40	1930	25.01	-1.39	-0.61	1964	29.23	-0.30	-0.52
1897	28.35	-0.08	-0.34	1931	26.79	-0.65	-0.64	1965	28.95	0.42	-0.39
1898	28.93	-0.31	-0.38	1932	29.60	0.26	-0.72	1966	26.67	-1.12	-0.28
1899	27.64	-0.70	-0.48	1933	26.80	-1.12	-0.90	1967	28.61	-0.13	-0.15
1900	30.02	-0.47	-0.55	1934	25.05	-2.06	-1.01	1968	29.52	0.36	0.00
1901	26.85	-0.83	-0.57	1935	28.85	-0.41	-0.89	1969	29.79	0.36	0.09
1902	29.63	-0.28	-0.55	1936	26.59	-1.15	-0.60	1970	28.54	-0.46	0.16
1903	28.54	-0.57	-0.42	1937	29.72	0.28	-0.33	1971	29.29	0.34	0.31
1904	27.09	-1.22	-0.07	1938	28.85	0.44	-0.18	1972	30.77	0.51	0.50
1905	32.14	1.14	0.41	1939	25.82	-1.47	-0.01	1973	33.99	1.45	0.58
1906	31.49	1.60	0.73	1940	29.63	0.52	0.24	1974	29.72	-0.29	0.46
1907	30.01	0.73	0.69	1941	31.85	1.69	0.39	1975	32.02	1.44	0.23
1908	29.07	0.25	0.34	1942	30.58	0.32	0.29	1976	25.62	-1.61	0.09
1909	29.95	0.67	-0.09	1943	26.07	-1.19	0.17	1977	29.62	0.52	0.15
1910	24.17	-2.29	-0.30	1944	30.08	0.43	0.24	1978	29.17	0.49	0.30
1911	28.81	0.22	-0.18	1945	32.25	1.12	0.38	1979	32.02	1.06	0.38
1912	29.56	0.58	0.10	1946	30.42	0.56	0.37	1980	27.38	-0.51	0.47
1913	29.12	0.48	0.30	1947	28.57	-0.37	0.25	1981	29.17	0.02	0.76
1914	28.01	-0.25	0.34	1948	29.65	0.36	0.15	1982	32.99	2.17	1.16
1915	31.69	1.28	0.19	1949	29.70	0.22	0.09	1983	33.81	2.13	1.31
1916	28.61	0.34	-0.11	1950	29.99	-0.30	-0.04	1984	30.48	0.87	1.10
1917	24.37	-2.44	-0.29	1951	30.33	0.80	-0.32	1985	29.41	0.48	0.70
1918	28.02	0.39	-0.14	1952	25.63	-1.63	-0.71	1986	30.61	0.61	0.25
1919	30.94	0.55	0.17	1953	27.51	-0.84	-1.06	1987	28.46	-0.04	-0.15
1920	30.37	0.89	0.35	1954	25.23	-1.70	-1.25	1988	25.25	-1.52	-0.32
1921	27.68	-0.26	0.34	1955	26.81	-1.04	-1.16	1989	28.42	-0.63	-0.10
1922	29.09	0.37	0.21	1956	24.57	-2.38	-0.78	1990	31.40	1.15	0.37
1923	30.78	1.20	-0.05	1957	32.90	1.39	-0.30	1991	31.77	0.90	0.78
1924	25.75	-1.75	-0.29	1958	29.25	0.12	-0.02	1992	30.67	1.02	0.97
1925	26.06	-0.80	-0.30	1959	29.88	-0.04	-0.01	1993	31.41	1.40	0.99
1926	29.95	0.33	-0.10	1960	27.95	-0.44	-0.14	1994	29.46	0.44	0.96
1927	30.93	1.07	0.00	1961	30.41	0.21	-0.33	1995	31.03	1.05	0.97
1928	28.59	-0.76	-0.16	1962	27.80	-0.52	-0.52	1996	32.60	1.18	1.02

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center, *Climate Variations Bulletin*, Vol. 7 (DOC, NOAA, NCDC, Asheville, NC, December 1996).

Notes: The U.S. national precipitation index is computed from data from the Cooperative Station Network. The contiguous United States is divided into 344 climate divisions. The monthly precipitation for all stations within each division is averaged to compute a divisional monthly precipitation. The divisional precipitation values are standardized using the gamma distribution over the 1931-90 period. The divisional standardized precipitation index values are then weighted by area to compute a national precipitation index value. A national annual value is computed from the monthly national values. The annual index values are then normalized over the period of record.

Table 6.2 Severe to Extreme Drought and Wetness in the Conterminous United States, 1900-1996

Year	Severe to extreme drought	Severe to extreme wetness	Year	Severe to extreme drought	Severe to extreme wetness	Year	Severe to extreme drought	Severe to extreme wetness
	% area			*% area*			*% area*	
1900	15.7	5.4	1933	13.6	3.2	1966	10.0	5.8
1901	19.8	3.4	1934	48.8	0.5	1967	7.3	5.2
1902	24.7	5.7	1935	23.4	3.1	1968	3.9	7.6
1903	7.9	11.8	1936	24.7	2.3	1969	0.9	10.7
1904	13.7	7.3	1937	19.6	5.1	1970	0.9	4.4
1905	6.9	17.7	1938	9.3	6.0	1971	5.2	8.6
1906	1.0	22.7	1939	19.4	2.9	1972	4.8	13.3
1907	0.9	26.4	1940	22.2	2.2	1973	3.2	31.2
1908	2.1	12.8	1941	11.6	26.0	1974	4.9	16.0
1909	4.4	16.0	1942	4.2	26.0	1975	0.5	20.8
1910	14.2	5.4	1943	4.2	10.0	1976	6.9	9.2
1911	18.3	3.8	1944	5.8	7.6	1977	22.7	4.7
1912	0.5	14.3	1945	2.7	17.0	1978	2.8	14.0
1913	3.3	13.8	1946	3.4	9.7	1979	1.1	21.9
1914	6.1	14.3	1947	4.7	11.6	1980	5.1	11.6
1915	3.8	24.1	1948	6.1	9.3	1981	13.1	4.5
1916	0.5	26.7	1949	4.8	6.2	1982	1.1	17.5
1917	8.5	14.8	1950	8.4	9.6	1983	0.0	36.0
1918	13.3	1.4	1951	12.3	14.6	1984	2.2	26.3
1919	5.2	11.3	1952	12.7	10.3	1985	2.9	21.0
1920	1.4	18.4	1953	19.9	4.1	1986	4.4	15.1
1921	2.8	6.4	1954	39.5	2.9	1987	7.8	16.5
1922	4.1	3.0	1955	29.4	1.5	1988	22.2	5.8
1923	4.4	8.1	1956	37.0	5.0	1989	18.7	6.9
1924	11.6	8.2	1957	15.5	10.5	1990	19.0	7.2
1925	16.7	0.7	1958	2.7	18.1	1991	9.2	9.0
1926	9.6	4.6	1959	11.1	4.4	1992	10.8	18.3
1927	5.3	15.9	1960	12.3	7.1	1993	1.2	35.1
1928	5.6	12.3	1961	14.6	7.7	1994	6.9	14.8
1929	6.8	10.8	1962	4.4	5.9	1995	1.6	24.8
1930	12.9	2.0	1963	18.4	2.0	1996	7.9	23.2
1931	30.0	5.3	1964	20.6	3.2			
1932	10.2	9.5	1965	7.6	13.7			

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center, *Climate Variations Bulletin*, Vol. 7 (DOC, NOAA, NCDC, Asheville, NC, December 1996).

Notes: This table presents the average annual values of the percent area experiencing severe to extreme drought and wet conditions based on the Palmer Drought Severity Index (PDSI). PDSI is based on a water balance model that consists of a hydrologic accounting between water supply and demand. The index values range from negative (indicating drought), to zero (near normal conditions), to positive (wet spell). The index has been calculated on a monthly basis for the contiguous United States since 1896.

Table 6.3 U.S. Water Use by Source and End-use Sector, 1900-1995

	Source		End-use sector					
Year	Ground water	Surface water	Public supply	Rural domestic and livestock	Irrigation	Thermoelectric utility	Commercial and other industrial	Total
			billions of gallons per day					
1900	na	na	3.0	2.0	20.0	5.0	10.0	40.0
1910	na	na	5.0	2.2	39.0	7.0	14.0	67.2
1920	na	na	6.0	2.4	56.0	9.0	18.0	91.4
1930	na	na	8.0	2.9	60.0	18.0	21.0	109.9
1940	na	na	10.0	3.1	71.0	23.0	29.0	136.1
1945	na	na	12.0	3.4	80.0	31.5	35.0	161.9
1950	34.0	150.0	14.0	3.6	89.0	40.0	37.0	183.6
1955	47.6	198.0	17.0	3.6	110.0	72.0	39.0	241.6
1960	50.4	221.0	21.0	3.6	110.0	100.0	38.0	272.6
1965	60.5	253.0	24.0	4.0	120.0	130.0	46.0	324.0
1970	69.0	303.0	27.0	4.5	130.0	170.0	47.0	378.5
1975	83.0	329.0	29.0	4.9	140.0	200.0	45.0	418.9
1980	83.9	361.0	34.0	5.6	150.0	210.0	45.0	444.6
1985	73.7	320.0	37.0	7.8	140.0	190.0	31.0	405.8
1990	80.6	327.2	38.5	7.9	137.0	195.0	29.9	408.8
1995	77.4	323.0	40.2	8.8	134.0	189.9	28.0	400.8

Sources: U.S. Department of Commerce, Bureau of the Census, *Historical Statistics of the United States: Colonial Times to 1970*, Series J 92-103 (GPO, Washington, DC, 1975).

Solley, W.B., *Preliminary Estimates of Water Use in the United States, 1995*, USGS Open-File Report 97-645 (U.S. Department of the Interior, Geological Survey, Reston, VA, 1997) and earlier reports in this series.

Note: na = not available. Totals may not agree with sum of components due to independent rounding.

Table 6.4 Designated-use Support in Surface Waters of the United States, 1996

Designated-use support	Rivers and streams *miles*	Lakes, ponds and reservoirs *acres*	Estuaries *square miles*
Fully supporting	386,161	7,787,615	14,586
Threatened	53,324	2,054,724	1,976
Impaired	201,558	4,357,127	7,358
Total surface waters surveyed	641,611	14,200,153	23,921
Total surface waters not surveyed	2,992,541	37,327,775	15,918
Total surface waters	3,634,152	41,654,902	39,839

Source: U.S. Environmental Protection Agency, Office of Water, *National Water Quality Inventory: 1996 Report to Congress* (EPA, OW, Washington, DC, 1998).

Table 6.5 Trends in U.S. Stream Water Quality, 1980-1989

Water quality indicators	NASQAN* stations analyzed	Flow-adjusted concentrations Upward trend	Downward trend	No trend
		number of stations		
Dissolved solids	340	28	46	266
Nitrate	344	22	27	295
Total phosphorus	410	19	92	299
Suspended sediments	324	5	37	282
Dissolved oxygen	424	38	26	360
Fecal coliform	313	10	40	263

Source: Smith, R.A., R.B. Alexander and K.J. Lanfear, "Stream Water Quality in the Conterminous United States -- Status and Trends of Selected Indicators During the 1980's," In *National Water Summary 1990-91, Hydrologic Events and Stream Water Quality*, R.W. Paulson, E.B. Chase, J.S. Williams and D.W. Moody, Compilers, Water Supply Paper 2400 (U.S. Department of the Interior, Geological Survey, Reston, VA, 1993), Figures 38-43.

Notes: *Analyses were made on data from the U.S. Geological Survey's National Stream Quality Accounting Network (NASQAN) stations. Data for total phosphorus cover the period 1982-1989.

Table 6.6 Ambient Water Quality in U.S. Rivers and Streams: Violation Rates, 1975-1995

Year	Fecal coliform bacteria	Dissolved oxygen	Total phosphorus	Total cadmium, dissolved	Total lead, dissolved
	percent of all measurements exceeding national water quality criteria				
1975	36	5	5	*	*
1976	32	6	5	*	*
1977	34	11	5	*	*
1978	35	5	5	*	*
1979	34	4	3	4	13
1980	31	5	4	1	5
1981	30	4	4	1	3
1982	33	5	3	1	2
1983	34	4	3	1	5
1984	30	3	4	<1	<1
1985	28	3	3	<1	<1
1986	24	3	3	<1	<1
1987	23	2	3	<1	<1
1988	22	2	4	<1	<1
1989	30	3	2	<1	<1
1990	26	2	3	<1	<1
1991	15	2	2	<1	<1
1992	28	2	2	<1	<1
1993	31	<1	2	na	na
1994	28	2	2	na	na
1995	35	1	4	na	na

Source: U.S. Geological Survey, national-level data, unpublished, Reston, VA, 1996.

Notes: *Base figure too small to meet statistical standards for reliability of derived figures. na = not available. Violation levels are based on the following U.S. Environmental Protection Agency water quality criteria: fecal coliform bacteria – above 200 cells per 100 ml; dissolved oxygen – below 5 milligrams per liter; total phosphorus – above 1.0 milligrams per liter; cadmium, dissolved – above 10 micrograms per liter; and total lead, dissolved – above 50 micrograms per liter.

Table 6.7 Estimated Phosphorus Loadings to the Great Lakes, 1976-1991

Year	Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario
			metric tons		
1976	3,550	6,656	4,802	18,480	12,695
1977	3,661	4,666	3,763	14,576	8,935
1978	5,990	6,245	5,255	19,431	9,547
1979	6,619	7,659	4,881	11,941	8,988
1980	6,412	6,574	5,307	14,855	8,579
1981	3,412	4,091	3,481	10,452	7,437
1982	3,160	4,084	4,689	12,349	8,891
1983	3,407	4,515	3,978	9,880	6,779
1984	3,642	3,611	3,452	12,874	7,948
1985	2,864	3,956	5,758	11,216	7,083
1986	3,059	4,981	4,210	11,118	9,561
1987	1,949	3,298	2,909	8,381	7,640
1988	2,067	2,907	3,165	7,841	6,521
1989	2,323	4,360	3,227	8,568	6,728
1990	1,750	3,006	2,639	12,899	8,542
1991	2,709	3,478	4,460	11,113	10,475

Source: Great Lakes Water Quality Board, *Great Lakes Water Quality Surveillance Subcommittee Report to the International Joint Commission*, United States and Canada, (International Joint Commission, Windsor, ON, Canada, biennial).

Notes: The 1978 Great Lakes Water Quality Agreement set target loadings for each lake (in metric tons per year): Lake Superior, 3,400; Lake Michigan, 5,600; Lake Huron, 4,360; Lake Erie, 11,000, and Lake Ontario, 7,000. Data do not include loadings to the St. Lawrence River. Data analysis was discontinued after 1991.

Table 6.8 Oil Polluting Incidents Reported In and Around U.S. Waters, 1970-1995

Year	Number	Volume	Year	Number	Volume
	thousands	*million gallons*		*thousands*	*million gallons*
1970	3.71	15.25	1983	7.92	8.38
1971	8.74	8.84	1984	8.26	18.01
1972	9.93	18.81	1985	6.17	8.44
1973	9.01	15.25	1986	4.99	4.28
1974	9.99	15.72	1987	4.84	3.61
1975	9.30	21.52	1988	5.00	6.59
1976	9.42	18.52	1989	6.61	13.48
1977	9.46	8.19	1990	8.18	7.97
1978	10.64	10.86	1991	8.57	3.76
1979	9.83	20.89	1992	9.49	1.88
1980	8.38	12.60	1993	8.97	2.07
1981	7.81	8.92	1994	9.44	19.51
1982	7.48	10.35	1995	6.49	1.98

Source: U.S. Department of Transportation, United States Coast Guard, Marine Safety and Environment Protection, G-MRI-1, Oil Spill Database, unpublished, Washington, DC, 1997.

Notes: Data for 1995 are preliminary. Includes oil spill data for vessels and non-vessels (e.g., facilities, pipelines, and other unknown sources).

Table 6.9 U.S. Shellfish Growing Waters, 1966-1995

Year	1966	1971	1974	1980	1985	1990	1995
				thousand acres			
Approved for harvest	8,100	10,362	10,560	10,685	11,402	12,304	14,853
Harvested limited	2,090	3,738	4,232	3,533	5,435	6,398	6,721
Conditionally approved	88	410	387	587	1,463	1,571	1,695
Restricted	na	30	34	55	637	463	2,106
Conditionally restricted	na	na	na	na	na	0	119
Prohibited	2,002	3,298	3,811	2,891	3,335	4,364	2,801
Total	10,190	14,100	14,792	14,218	16,837	18,702	21,574

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Survey, Office of Ocean Resources Conservation and Assessment, Strategic Environmental Assessments Division, *The 1995 National Shellfish Register of Classified Growing Waters* (DOC, NOAA, ORCA, Silver Spring, MD, 1997).

Notes: Based on National Shellfish Registers published only in years indicated. Data do not include Alaska, Hawaii, or waters designated as unclassified. The total acreage of classified shellfish growing waters varies with each register. There may be several reasons why shellfish harvest is prohibited, including water quality problems, lack of funding for complete surveying and monitoring, conservation measures, and other management/administrative actions.

Table 6.10 Status of Stock Levels of U.S. Fisheries, 1992-1994

Fishery	Current status relative to the level producing LTPY				
	Below	Near	Above	Unknown	Total
	number of species				
Northeast demersals	19	3	2	1	25
Northeast pelagics	1	2	3	0	6
Atlantic anadromous	4	0	1	0	5
Northeast invertebrates	0	3	2	1	6
Atlantic highly migratory pelagics	4	4	0	2	10
Atlantic sharks	1	0	1	1	3
Atlantic/Gulf coastal migratory pelagics	1	3	0	3	7
Atlantic/Gulf reef fish	9	2	0	17	28
Southeast drum and croaker	4	0	0	3	7
Southeast menhaden	0	2	0	0	2
Southeast/Caribbean invertebrates	3	6	0	5	14
Pacific coast salmon	2	3	0	0	5
Alaska salmon	1	1	3	0	5
Pacific coast and Alaska pelagics	3	4	0	0	7
Pacific coast groundfish	6	4	4	5	19
Western Pacific invertebrates	1	0	0	0	1
Western Pacific bottomfish*	3	3	0	0	6
Pacific highly migratory pelagics	2	12	0	1	15
Alaska groundfish	6	8	8	3	25
Alaska shellfish	3	0	1	1	5
Subtotal	73	60	25	43	201
Nearshore species	10	14	0	50	74
Total assessed species	83	74	25	93	275

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, *Our Living Oceans, Report on the Status of U.S. Living Marine Resources, 1995*, NOAA Technical Memorandum NMFS-F/SPO-19 (DOC, NOAA, NMFS, Washington, DC, 1996).

Notes: LTPY is long-term potential yield or the maximum long-term average catch that can be achieved from the resource. This term is analogous to the concept of maximum sustainable yield. Stock level relative to LTPY is a measure of stock status. The present abundance level of the stock is compared with the level of abundance which on average would support the LTPY harvest. This level is expressed as below, near, above, or unknown relative to the abundance level that would produce LTPY. Demersal = bottom-dwelling fishes such as flounders, skates, and dogfish. Pelagic = mid-water fishes such as blue fish, anchovies, sardines, and squids. Anadromous = fishes which ascend rivers to spawn, such as salmon, shad, and striped bass. Invertebrates = lobsters, clams, scallops, shrimp, etc. Highly migratory = high-seas (oceanic) fishes such as tunas, swordfish, and billfishes. Coastal migratory = fishes that range from the shore to the outer edge of the U.S. continental shelf, such as king and Spanish mackeral, dolphin fish, and cobia. Reef fish = fishes that prefer coral reefs, artificial structures, and other hard bottom areas, such as snappers, groupers, and amberjacks. Reef fish also include tilefishes that prefer sand bottom areas. *Also includes armorhead.

Table 6.11 Waterborne Disease Outbreaks and Cases in the United States, 1971-1994

Year	Waterborne disease outbreaks by water supply system: Community	Non-community	Individual	Total	Total cases
	number				*number*
1971	8	8	4	20	5,184
1972	9	19	2	30	1,650
1973	6	16	3	25	1,762
1974	11	9	5	25	8,356
1975	6	16	2	24	10,879
1976	9	23	3	35	5,068
1977	14	18	2	34	3,860
1978	10	19	3	32	11,435
1979	24	13	8	45	9,841
1980	26	20	7	53	20,045
1981	14	18	4	36	4,537
1982	26	15	3	44	3,588
1983	30	9	4	43	21,036
1984	12	5	10	27	1,800
1985	7	14	1	22	1,946
1986	10	10	2	22	1,569
1987	8	6	1	15	22,149
1988	6	10	1	16	2,169
1989	6	6	1	13	2,670
1990	6	7	2	15	1,748
1991	2	13	0	15	12,960
1992	6	10	3	19	4,504
1993	9	4	5	18	404,190
1994	5	5	2	12	649

Source: M.H. Kramer, B.L. Herwaldt, G.F. Craun, R.L. Calderon and D.D. Juranek, "Surveillance for Waterborne-Disease Outbreaks—United States, 1993-1994," in *CDC Surveillance Summaries*, April 12, 1996, Morbidity and Mortality Weekly Report 42(SS-5) (U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, Atlanta, GA), pp. 7-8, and earlier reports in this series.

Notes: The number of waterborne disease outbreaks and the number of affected people or cases reported to the Centers for Disease Control and Prevention and to the U.S. Environmental Protection Agency represents a fraction of the total number that occur. Therefore, these data should not be used to draw firm conclusions about the true incidence of waterborne disease outbreaks.

Table 6.12 U.S. Wetlands by Type, Mid-1950s to Mid-1990s

Wetlands type	Mid-1950s	Mid-1970s	Mid-1980s	Mid-1990s
			million acres	
Estuarine wetlands	5.59	5.53	5.10	5.09
Palustrine marshes	33.07	24.31	25.88	25.01
Palustrine shrub wetlands	11.00	15.51	15.60	17.07
Palustrine forested wetlands	55.09	55.15	50.39	47.93
Other palustrine wetlands	2.70	5.35	5.14	5.79
Total wetland acreage	107.45	105.85	102.12	100.91

Sources: Dahl, T.E., R.D. Young and M.C. Caldwell, *Status and Trends of Wetlands in the Conterminous United States, 1980s to 1990s* (U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC, Draft).

Dahl, T.E. and C.E. Johnson, *Status and Trends of Wetlands in the Conterminous United States, 1970s to 1980s* (U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC, 1991).

Frayer, W.E., T.J. Monahan, D.C. Bowden and F.A. Graybill, *Status and Trends of Wetlands and Deepwater Habitats in the Conterminous United States, 1950s to 1970s* (Colorado State University, Fort Collins, CO, 1983).

Note: Totals may not agree with sum of components due to independent rounding.

Table 6.13 Wetlands Losses by Current State Boundaries, 1780s-1980s

State	Total surface area of state	Wetlands area 1780s	Wetlands area 1980s	Wetlands losses
		million acres		%
Alabama	33.03	7.57	3.78	50
Alaska	375.30	170.20	170.00	<1
Arizona	72.90	0.93	0.60	36
Arkansas	33.99	9.85	2.76	72
California	101.56	5.00	0.45	91
Colorado	66.72	2.00	1.00	50
Connecticut	3.21	0.67	0.17	74
Delaware	1.32	0.48	0.22	54
Florida	37.48	20.33	11.04	46
Georgia	37.68	6.84	5.30	23
Hawaii	4.12	0.06	0.05	12
Idaho	53.47	0.88	0.39	56
Illinois	36.10	8.21	1.25	85
Indiana	23.23	5.60	0.75	87
Iowa	36.03	4.00	0.42	89
Kansas	52.65	0.84	0.44	48
Kentucky	25.85	1.57	0.30	81
Louisiana	31.05	16.19	8.78	46

See next page for continuation of table.

Table 6.13 Wetlands Losses by Current State Boundaries, 1780s-1980s (continued)

State	Total surface area of state	Wetlands area 1780s	Wetlands area 1980s	Wetlands losses
	million acres			%
Maine	21.26	6.46	5.20	20
Maryland	6.77	1.65	0.44	73
Massachusetts	5.28	0.82	0.59	28
Michigan	37.26	11.20	5.58	50
Minnesota	53.80	15.07	8.70	42
Mississippi	30.54	9.87	4.07	59
Missouri	44.60	4.84	0.64	87
Montana	94.17	1.15	0.84	27
Nebraska	49.43	2.91	1.91	35
Nevada	70.75	0.49	0.24	52
New Hampshire	5.95	0.22	0.20	9
New Jersey	5.02	1.50	0.92	39
New Mexico	77.87	0.72	0.48	33
New York	31.73	2.56	1.03	60
North Carolina	33.66	11.09	5.69	49
North Dakota	45.23	4.93	2.49	49
Ohio	26.38	5.00	0.48	90
Oklahoma	44.75	2.84	0.95	67
Oregon	62.07	2.26	1.39	38
Pennsylvania	29.01	1.13	0.50	56
Rhode Island	0.78	0.10	0.07	37
South Carolina	19.88	6.41	4.66	27
South Dakota	49.31	2.74	1.78	35
Tennessee	27.04	1.94	0.79	59
Texas	171.10	16.00	7.61	52
Utah	54.35	0.80	0.56	30
Vermont	6.15	0.34	0.22	35
Virginia	26.12	1.85	1.07	42
Washington	43.64	1.35	0.94	31
West Virginia	15.48	0.13	0.10	24
Wisconsin	35.94	9.80	5.33	46
Wyoming	62.66	2.00	1.25	38

Source: Dahl, T.E., *Wetlands Losses in the United States 1780s to 1980s* (U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC, 1991).

Table 6.14 Average Annual Acres of U.S. Wetlands Converted to Upland Uses, Mid-1950s to Mid-1990s

Post-conversion land use	1954-1974[1]	1974-1983[2]	1985-1995[3]
	thousands of acres per year (average)		
Agriculture	398.5	156.6	na
Urban use	36.6	14.5	na
Other upland uses	23.4	118.9	na
Total	458.0	290.0	117.0
	percent of average annual conversion		
Agriculture	87	54	na
Urban use	8	5	na
Other upland uses	5	41	na
Total	100	100	100

Sources: [1]Frayer, W.E., T.J. Monahan, D.C. Bowden and F.A. Graybill, *Status and Trends of Wetlands and Deepwater Habitats in the Conterminous United States, 1950s to 1970s* (U.S. Department of the Interior, Fish and Wildlife Service, Fort Collins, CO, 1983).

[2]Dahl, T.E. and C.E. Johnson, *Status and Trends of Wetlands in the Conterminous United States, 1970s to 1980s* (U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC, 1991).

[3]Dahl, T.E., R.D. Young and M.C. Caldwell, *Status and Trends of Wetlands in the Conterminous United States, 1980s to 1990s* (U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC, Draft).

Notes: Data reflect net wetlands losses (= losses plus gains) by category. Other upland uses include silvicultural activities, residential and recreational development in rural areas, and highway construction and improvements in rural areas. A significant portion of lands classified as "other" in the 1970s-1980s study were wetlands that had been drained and cleared of vegetation, but the land had not been put to an identifiable use (as determined by interpretation of aerial photography and groundtruthing).

Terrestrial Resources

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Table 7.1 Land Use and Ownership in the United States, 1900-1992

	Land use					Ownership	
Year	Crop-land	Grazing land	Forest-land	Other land	Total	Private & other public	Federal
			million acres			%	
1900	319	1,044	366	175	1,904	52.7	47.3
1910	347	814	562	181	1,904	68.5	31.5
1920	402	750	567	185	1,904	73.8	26.2
1930	413	708	607	176	1,904	74.0	26.0
1945	451	660	602	193	1,905	73.7	26.3
1949	478	631	606	189	1,904	73.5	26.5
1954	465	632	615	191	1,904	73.5	26.5
1959	458	633	728	452	2,271	61.0	39.0
1964	444	640	732	450	2,266	60.4	39.6
1969	472	604	723	465	2,264	66.5	33.5
1974	465	598	718	483	2,264	66.5	33.5
1978	471	587	703	503	2,264	67.2	32.9
1982	469	597	655	544	2,265	67.9	32.2
1987	464	591	648	562	2,265	68.1	31.9
1992	460	591	648	564	2,263	71.3	28.7

Sources: Daugherty, A.B., *Major Uses of Land in the United States: 1992*, Table 3, p. 4, Agricultural Economic Report No. 723 (GPO, Washington, DC, 1995) and earlier reports in this series.

U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States* (GPO, Washington, DC, annual).

Notes: Prior to 1959, excludes Alaska and Hawaii. Other changes in total land area result from refinements in measuring techniques. Federal includes original public-domain lands vested in the U.S. government by virtue of its sovereignty as well as lands acquired by the U.S. government by purchase, condemnation, and gift. Historical estimates are based on imperfect data. Other land includes rural transportation areas, areas used primarily for recreation and wildlife purposes, various public installations and facilities, farmsteads and farm roads, urban areas, areas in miscellaneous uses not inventoried, marshes, open swamps, bare rock areas, desert, tundra, and other land generally having low value for agricultural purposes. Land-use and land-ownership estimates are not strictly comparable. Totals may not agree with sum of components due to independent rounding.

Table 7.2 Special Uses of Land in the United States, 1945-1992

Land use	1945	1949	1959	1969	1974	1978	1982	1987	1992
					million acres				
Transportation	22.6	22.9	25.2	26.0	26.3	26.6	26.7	25.7	25.2
Parks & wildlife	22.6	27.6	46.9	81.3	87.5	98.0	211.0	224.9	228.9
National defense	24.8	21.5	31.2	25.6	25.0	24.9	24.0	20.9	20.5
Urban	15.0	18.3	27.2	31.0	34.8	44.6	50.2	56.6	58.8
Farmsteads	15.1	15.1	11.4	10.3	8.1	8.4	8.0	7.1	6.2
Total	100.0	105.4	141.9	174.2	181.7	202.5	319.9	335.2	339.5

Source: Daugherty, A.B., *Major Uses of Land in the United States: 1992*, Table 14, p. 17, Agricultural Economic Report No. 723 (GPO, Washington, DC, 1995) and earlier reports in this series.

Note: Categories of special-use lands are a subset of those listed as other in Table 7.1.

Table 7.3 Number of Farms and Land in Farms in the United States, 1900-1992

	Farm size									
	1 - 49 acres		50 - 499 acres		500 - 999 acres		1,000 + acres		Total	
Year	Number	Acres	Number	Acres	Number	Acres	Number	Acres	Number	Acres
					millions					
1900	1.93	49	3.37	520	0.10	68	0.05	200	5.74	837
1910	2.25	49	3.93	570	0.13	84	0.05	167	6.37	870
1920	2.31	59	3.93	580	0.15	100	0.07	221	6.45	960
1925	2.42	57	3.75	550	0.14	97	0.06	224	6.37	928
1930	2.36	56	3.69	550	0.16	109	0.08	277	6.30	992
1935	2.69	59	3.86	540	0.17	114	0.09	310	6.81	1,023
1940	2.29	50	3.55	540	0.16	112	0.10	366	6.10	1,068
1945	2.25	47	3.32	520	0.17	119	0.11	460	5.86	1,146
1950	1.97	39	3.12	500	0.18	126	0.12	495	5.39	1,160
1954	1.70	32	2.76	460	0.19	132	0.13	531	4.78	1,155
1959	1.06	22	2.32	410	0.20	137	0.14	555	3.71	1,124
1964	0.82	17	1.98	360	0.21	145	0.15	585	3.16	1,107
1969	0.64	14	1.73	320	0.22	148	0.15	578	2.73	1,060
1974	0.51	11	1.44	273	0.21	142	0.16	590	2.31	1,024
1978	0.54	12	1.34	256	0.21	147	0.16	600	2.26	1,015
1982	0.64	13	1.24	233	0.20	141	0.16	600	2.24	987
1987	0.60	12	1.12	212	0.20	139	0.17	602	2.09	965
1992	0.56	11	1.01	190	0.19	129	0.17	615	1.93	945

Sources: U.S. Department of Commerce, Bureau of the Census, *Historical Statistics of the United States: Colonial Times to 1970* (GPO, Washington, DC, 1975).

--, *Census of Agriculture for 1992, Vol. I: Geographic Area Series, Part 51 United States Summary and State Data*, Table 8, p. 18, AC92-A-51 (GPO, Washington, DC, 1994) and earlier census reports.

Table 7.4 Major Uses of U.S. Cropland, Agricultural Census Years, 1945-1992, and Annually, 1993-1996

	Cropland used for crops						Cropland
Year	Harvested	Failed	Cultivated summer fallow	Idle cropland	Cropland pasture	Total	Cropland idled by federal programs
				million acres			
1945	336	9	18	40	47	454	4.1
1949	352	9	26	22	67	478	0.0
1954	339	13	28	19	66	465	0.0
1959	317	10	31	33	66	457	22.5
1964	292	6	37	52	57	444	55.0
1969	286	6	41	51	88	472	57.5
1974	322	8	31	21	83	465	2.7
1978	330	7	32	26	76	471	18.3
1982	347	5	31	21	65	469	11.1
1987	293	6	32	68	65	464	76.2
1992	305	8	24	56	67	460	54.9
1993	297	11	22	na	na	na	59.8
1994	310	7	22	na	na	na	49.2
1995	302	8	22	na	na	na	54.8
1996	314	10	22	na	na	na	34.4

Sources: U.S. Department of Agriculture, Economic Research Service, *AREI Updates: Cropland Use in 1996*, Table 1, p. 2 (USDA, ERS, Washington, DC, 1996).

U.S. Department of Commerce, Bureau of the Census, *Census of Agriculture for 1992, Vol. I: Geographic Area Series, Part 51 United States Summary and State Data*, Table 7, p. 17, AC92-A-51 (GPO, Washington, DC, 1994) and earlier census reports.

Notes: na = not available except in years coinciding with Census of Agriculture. Excludes Alaska and Hawaii. A double-cropped acre is counted as one acre. Cropland has been idled under various federal farm programs including the Agricultural Conservation Program (1936-1947), Soil Bank (1956-1970), Cropland Adjustment Program (1961-1977), Agricultural Reduction Program (1961-1995), and Conservation Reserve Program (1986-1996).

Table 7.5 Cropland Tillage Practices Used in Production of U.S. Field Crops, 1989-1996

	Total area planted	Conventional tillage	Reduced tillage	Conservation tillage: No-till	Ridge-till	Mulch-till	Total
	million acres						
1989	279.6	137.3	70.7	14.1	2.7	54.7	71.7
1990	280.9	136.7	71.0	16.9	3.0	53.3	73.2
1991	281.2	129.8	72.3	20.6	3.2	55.3	79.1
1992	282.9	120.8	73.4	28.1	3.4	57.3	88.7
1993	278.1	107.9	73.2	34.8	3.5	58.9	97.1
1994	283.9	111.4	73.2	39.0	3.6	56.8	99.3
1995	278.7	109.7	70.1	40.9	3.4	54.6	98.9
1996	290.2	111.6	74.8	42.9	3.4	57.5	103.8
	percent of planted acres						
1989	100	49.1	25.3	5.1	1.0	19.6	25.6
1990	100	48.7	25.3	6.0	1.1	19.0	26.1
1991	100	46.1	25.7	7.3	1.1	19.7	28.1
1992	100	42.7	25.9	9.9	1.2	20.2	31.4
1993	100	38.8	26.3	12.5	1.2	21.2	34.9
1994	100	39.3	25.8	13.7	1.3	20.0	35.0
1995	100	39.3	25.2	14.7	1.2	19.6	35.5
1996	100	38.4	25.8	14.8	1.2	19.8	35.8

Source: Conservation Technology Information Center, *National Crop Residue Management Survey Annual Report* (CTIC, West Lafayette, IN, annual).

Notes: Conventional tillage is practiced with or without moldboard plow and leaves less than 15 percent residue after planting. Reduced tillage leaves 15-30 percent residue after planting. Conservation tillage leaves over 30 percent residue after planting. Conservation tillage includes no till (the soil is left undisturbed prior to planting, except for nutrient injection, and planting or drilling is accomplished in a narrow seedbed or slot created by coulters, row openers, disk openers, inrow chisels, or rototillers), ridge till (the soil is left undisturbed prior to planting, except for nutrient injection, and planting is completed in a seedbed prepared on ridges with sweeps, disk openers, coulters, or row cleaners; residue is left on the surface between ridges), and mulch till (the surface is disturbed before planting but 30 percent or more residue remains after planting).

Table 7.6 Erosion on U.S. Cropland, 1982-1992

Year	Sheet and rill erosion: *billion tons per year*	*tons per acre per year*	Wind erosion: *billion tons per year*	*tons per acre per year*
1982	1.7	4.1	1.4	3.3
1987	1.5	3.7	1.3	3.2
1992	1.2	3.1	0.9	2.5

Source: U.S. Department of Agriculture, National Resource Conservation Service, *Summary Report 1992 National Resources Inventory* (USDA, NRCS, Washington, DC, 1995).

Table 7.7 U.S. Agricultural Productivity Indexes, 1960-1994

	Farm input				Farm output			Total
Year	Purchased input	Labor	Capital	Total	Crops	Live-stock	Total	Total produc-tivity
				index (1987=100)				
1960	78	222	101	112	56	72	62	56
1961	74	215	99	109	57	75	64	58
1962	77	213	98	109	57	76	64	59
1963	80	207	98	110	59	78	66	60
1964	78	196	98	108	57	80	66	61
1965	76	190	99	107	61	78	67	63
1966	83	178	100	108	60	79	67	62
1967	83	169	102	107	63	81	70	65
1968	84	163	103	105	65	82	71	67
1969	88	160	103	106	67	82	72	68
1970	91	158	103	107	64	85	72	68
1971	88	155	105	106	71	86	76	72
1972	91	153	104	106	71	87	77	72
1973	91	154	107	109	76	88	80	74
1974	90	143	110	108	70	87	76	70
1975	86	143	111	106	79	82	80	76
1976	90	141	112	110	79	86	81	74
1977	86	136	114	108	86	88	86	80
1978	99	130	114	114	88	88	88	77
1979	106	126	115	117	97	89	93	80
1980	112	122	118	118	88	93	90	76
1981	106	124	118	115	101	95	98	85
1982	110	118	116	112	102	94	98	88
1983	112	116	109	109	80	96	86	79
1984	100	114	111	108	100	95	97	90
1985	102	107	110	105	105	97	102	96
1986	102	101	106	102	99	98	98	97
1987	100	100	100	100	100	100	100	100
1988	99	107	98	100	88	102	94	94
1989	94	102	97	98	101	103	102	103
1990	102	101	96	100	108	104	106	107
1991	102	104	96	101	107	107	107	106
1992	103	98	95	99	117	109	114	115
1993	104	94	93	100	104	110	107	107
1994	106	94	92	101	124	114	120	119

Source: U.S. Department of Agriculture, Economic Research Service, *Agricultural Outlook* (USDA, ERS, Washington, DC, monthly).

Notes: Purchased input includes chemicals, fuels, electricity, feed, seed, and livestock purchases; contract labor and custom machine services; machine and building maintenance and repair; irrigation from public sellers of water, and miscellaneous farm production items. Labor includes both hired and self-employed labor. Capital includes durable equipment and real estate. Livestock output includes meat animals, dairy products, poultry, eggs, wool, mohair, horses, mules, goats, sheep, rabbits, fur animals, aquaculture, honey, and beeswax. Crop outputs include food grains, feed grains, oil crops, sugar crops, cotton, cottonseed, vegetables, fruit trees, nut trees, tobacco, floriculture, ornamentals, Christmas trees, mushrooms, legume seeds, grass seeds, hops, mint, broomcorn, popcorn, hemp, and flax. Productivity = output/input.

Table 7.8 Farm Fuel Purchased for U.S. Farm Use, 1974-1995

Year	Gasoline	Diesel	Liquefied petroleum gas
		billion gallons	
1974	3.7	2.5	1.4
1975	4.5	2.4	1.0
1976	3.9	2.8	1.2
1977	3.8	2.9	1.1
1978	3.6	3.2	1.3
1979	3.4	3.2	1.1
1980	3.0	3.2	1.1
1981	2.7	3.1	1.0
1982	2.4	2.9	1.1
1983	2.3	3.0	0.9
1984	2.1	3.0	0.9
1985	1.9	2.9	0.9
1986	1.7	2.9	0.7
1987	1.5	3.0	0.6
1988	1.6	2.8	0.6
1989	1.3	2.5	0.7
1990	1.5	2.7	0.6
1991	1.4	2.8	0.6
1992	1.6	3.1	0.9
1993	1.4	3.3	0.7
1994	1.4	3.5	0.9
1995	1.4	3.6	0.8

Sources: U.S. Department of Agriculture (USDA), Economic Research Service (ERS), *AREI Updates: Farm Fuel and Ethanol*, No. 15, Table 1, p. 3 (USDA, ERS, Washington, DC, December 1996).

Notes: Excludes Alaska and Hawaii and fuel used for household and personal business. Data are based on USDA, National Agricultural Statistics Service, Farm Production Expenditures Survey data.

Table 7.9 U.S. Commercial Fertilizer Use, 1960-1996

Year	Total quantity	Active ingredients			
		Nitrogen	Phosphate	Potash	Total
	million tons	*million tons*			
1960	24.9	2.7	2.6	2.2	7.5
1961	25.6	3.0	2.6	2.2	7.8
1962	26.6	3.4	2.8	2.3	8.4
1963	28.8	3.9	3.1	2.5	9.5
1964	30.7	4.4	3.4	2.7	10.5
1965	31.8	4.6	3.5	2.8	10.9
1966	34.5	5.3	3.9	3.2	12.4
1967	37.1	6.0	4.3	3.6	14.0
1968	38.7	6.8	4.5	3.8	15.0
1969	38.9	7.0	4.7	3.9	15.5
1970	39.6	7.5	4.6	4.0	16.1
1971	41.1	8.1	4.8	4.2	17.2
1972	41.2	8.0	4.9	4.3	17.2
1973	43.3	8.3	5.1	4.6	18.0
1974	47.1	9.2	5.1	5.1	19.3
1975	42.5	8.6	4.5	4.5	17.6
1976	49.2	10.4	5.2	5.2	20.8
1977	51.6	10.6	5.6	5.8	22.1
1978	47.5	10.0	5.1	5.5	20.6
1979	51.5	10.7	5.6	6.2	22.6
1980	52.8	11.4	5.4	6.2	23.1
1981	54.0	11.9	5.4	6.3	23.7
1982	48.7	11.0	4.8	5.6	21.4
1983	41.8	9.1	4.1	4.8	18.1
1984	50.1	11.1	4.9	5.8	21.8
1985	49.1	11.5	4.7	5.6	21.7
1986	44.1	10.4	4.2	5.1	19.7
1987	43.0	10.2	4.0	4.8	19.1
1988	44.5	10.5	4.1	5.0	19.6
1989	44.8	10.6	4.1	4.8	19.5
1990	47.7	11.1	4.3	5.2	20.6
1991	47.3	11.3	4.2	5.0	20.5
1992	48.8	11.5	4.2	5.0	20.7
1993	49.2	11.4	4.4	5.1	20.9
1994	52.3	12.6	4.5	5.3	22.4
1995	50.7	11.7	4.4	5.1	21.3
1996	53.4	12.3	4.5	5.2	22.0

Sources: Tennessee Valley Authority, Environmental Research Center, *Commercial Fertilizers, 1994* (TVA, Oak Ridge, TN, 1995) and earlier issues.

The Association of American Plant Food Control Officials (AAPFCO), *Commercial Fertilizers, 1996* (AAPFCO, Lexington, KY, 1997) and earlier issues.

U.S. Department of Agriculture, Economic Research Service, *AREI UPDATES: Nutrient Use and Practices on Major Field Crops*, Table 1, p. 2 (USDA, ERS, Washington, DC, 1997).

Notes: Quantity refers to total fertilizer materials. Fertilizer use estimates for 1960-1984 are based on USDA data, those for 1985-1994 are TVA estimates, and 1995-1996 are from AAPFCO. Includes fertilizer use on farms, lawns, golf courses, home gardens, and other nonfarm lands. Includes Puerto Rico.

Table 7.10 U.S. Commercial Pesticide Use by Sector and Type, 1979-1995

	Agriculture						Industry, commercial, & government					
	Herbi-cides	In-secti-cides	Fungi-cides	Other con-ven.	Other chem-icals	Total	Herbi-cides	In-secti-cides	Fungi-cides	Other con-ven.	Other chem-icals	Total
	million pounds of active ingredients											
1979	492	188	57	106	246	1,089	85	35	50	46	27	243
1980	504	163	59	100	227	1,053	83	35	45	46	25	234
1981	513	152	62	104	215	1,046	82	37	43	46	24	232
1982	503	142	59	101	207	1,012	80	39	41	45	24	229
1983	455	135	59	100	196	945	80	40	40	45	24	229
1984	516	129	56	100	194	995	78	41	38	41	24	222
1985	501	126	59	94	194	974	70	43	37	41	23	214
1986	481	121	59	94	188	943	68	45	36	41	23	213
1987	425	90	52	91	180	838	65	42	34	39	22	202
1988	450	100	54	95	177	876	64	41	32	39	22	198
1989	460	95	54	113	161	883	63	40	31	38	22	194
1990	455	90	50	133	164	892	63	39	31	38	22	193
1991	440	85	47	144	140	856	60	38	30	37	21	186
1992	450	90	45	150	161	896	58	35	28	36	21	178
1993	425	80	47	154	166	872	56	32	25	36	20	169
1994	485	90	48	163	163	949	52	30	23	34	20	159
1995	461	91	49	170	168	939	48	29	20	31	22	150

	Home & garden						Total					
	Herbi-cides	In-secti-cides	Fungi-cides	Other con-ven.	Other chem-icals	Total	Herbi-cides	In-secti-cides	Fungi-cides	Other con-ven.	Other chem-icals	Total
	million pounds of active ingredients											
1979	33	32	17	3	70	155	610	255	124	155	343	1,487
1980	35	30	18	3	69	155	622	228	122	149	321	1,442
1981	36	29	17	3	68	153	631	218	122	152	307	1,430
1982	37	29	17	3	67	153	620	210	117	149	298	1,394
1983	38	29	16	3	67	153	573	204	115	148	287	1,327
1984	40	27	15	3	67	152	634	197	109	145	284	1,369
1985	40	24	14	3	67	148	611	193	110	138	284	1,336
1986	41	22	14	3	67	147	590	188	109	138	278	1,303
1987	42	20	14	3	67	146	532	152	100	133	269	1,186
1988	43	20	13	3	67	146	557	161	99	137	266	1,220
1989	44	19	13	2	68	146	567	154	98	154	251	1,224
1990	46	19	10	2	66	143	564	148	91	173	252	1,228
1991	46	18	9	2	65	140	546	141	86	182	226	1,181
1992	46	18	8	2	64	138	554	143	81	189	246	1,213
1993	46	18	8	2	62	136	527	130	80	192	248	1,177
1994	46	18	8	2	61	135	583	138	79	199	244	1,243
1995	47	17	8	2	59	133	556	137	77	203	249	1,222

Source: Aspelin, A.L., *Pesticide Industry Sales and Usage: 1994 and 1995 Market Estimates*, (U.S. Environmental Protection Agency, Washington, DC, 1997).

Notes: Other conven. = other conventional pesticides. Other chemicals = chemicals produced mainly for other purposes but also used as pesticides (e.g., chlorine, sulfur).

Table 7.11 Irrigated U.S. Farmland, Agricultural Census Years, 1890-1987, and Annually, 1988-1996

Year	Seventeen Western states	Other states	Total
		million acres	
1890	3.5	0.1	3.5
1900	7.5	0.3	7.8
1910	11.3	0.4	11.7
1920	13.9	0.5	14.5
1930	14.1	0.6	14.7
1940	17.2	0.7	18.0
1950	24.3	1.5	25.8
1959	30.7	2.4	33.2
1964	33.2	3.9	37.1
1969	34.8	4.3	39.1
1974	36.6	4.6	41.2
1978	43.2	7.2	50.3
1982	41.3	7.7	49.0
1987	37.5	8.9	46.4
1988	38.9	9.7	48.6
1989	40.0	9.5	49.5
1990	39.4	9.8	49.2
1991	39.9	10.1	50.0
1992	39.1	10.3	49.4
1993	39.6	10.2	49.8
1994	40.8	11.0	51.8
1995	41.2	10.8	52.0
1996	42.2	11.1	53.3

Sources: U.S. Department of Agriculture, Economic Research Service, *Agricultural Resources and Environmental Indicators, 1996-97*, AH-712 (USDA, ERS, Washington, DC, 1997) and earlier ERS reports.

U.S. Department of Commerce, Bureau of the Census, *Census of Agriculture for 1992, Vol. I: Geographic Area Series, Part 51 United States Summary and State Data*, Table 9, p. 18, AC92-A-51 (GPO, Washington, DC, 1994) and earlier census reports.

Notes: The seventeen Western states include Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming. Data for 1890-1982, 1987, and 1992 are from the Census of Agriculture. Data for other years are estimates constructed from data provided by the USDA, National Agricultural Statistics Service (NASS). Estimate for 1996 is a forecast based on normal weather conditions.

Table 7.12 Condition of U.S. Nonfederal Rangeland, Selected Years, 1963-1992, and Bureau of Land Management Rangeland, Selected Years, 1936-1996

Rangeland	Nonfederal					Bureau of Land Management				
condition	1963	1977	1982	1987	1992	1936	1966	1975	1986	1996
	% rangeland acreage									
Excellent	5	12	4	3	6	2	2	2	4	5
Good	15	28	30	30	34	14	17	15	30	33
Fair	40	42	45	47	44	48	52	50	41	39
Poor	40	18	16	14	15	36	30	33	18	14
Unclassified	na	na	5	6	1	na	na	na	na	9

Sources: U.S. Department of Agriculture, Natural Resources Conservation Service, *National Resources Inventory* (USDA, NRCS, Washington, DC, 1977, 1982, 1987, and 1992).

U.S. Department of the Interior, Bureau of Land Management, *Public Land Statistics* (DOI, BLM, Washington, DC, annual).

Notes: na = not available. Rangeland condition refers to the present state of the vegetation at a rangeland site in relation to the climax (natural potential) plant community for that site. It is expressed as the degree of similarity of present vegetation to the climax plant community. Excellent (equivalent to Potential Natural Community) = 76-100% similarity; Good (Late Seral) = 51-75% similarity; Fair (Mid Seral) = 26-50% similarity; and Poor (Early Seral) = 0-25% similarity. Unclassified includes rangeland for which data and estimates are not available, dry lakebeds, rock outcrops, and other areas for which data cannot be gathered. NRI is conducted every five years; BLM data are updated annually to reflect new information and changes in rangeland condition classes. NRI and BLM data are not strictly comparable because of different survey methodologies.

Table 7.13 Timberland in the United States by Ownership, 1952-1992

Year	Farmer and other private	Forest industry	National forests	Other public	Total
			million acres		
1952	304.5	59.0	94.7	50.7	508.9
1962	307.5	61.4	96.8	49.3	515.1
1977	285.3	68.9	88.7	49.5	491.1
1987	283.6	70.3	85.2	45.8	484.9
1992	287.6	70.5	84.7	46.8	489.6

Source: Powell, D.S., J.L. Faulkner, D.R. Darr, Z. Zhu and D.W. MacCleery, *Forest Statistics of the United States, 1992*, General Technical Report RM 234 (U.S. Department of Agriculture, Forest Service, Washington, DC, 1993).

Table 7.14 Annual Net Growth and Removals of U.S. Growing Stock, 1952-1991, and Volume of U.S. Growing Stock, 1952-1992

	Net growth and removals of growing stock									
	Farmer and other private		Forest industry		National forests		Other public		Total	
Year	Net Growth	Re-movals	Net Growth	Re-movals	Net Growth	Re-movals	Net Growth	Re-movals	Net Growth	Re-movals
					billion cubic feet					
1952	8.1	6.9	2.6	3.3	2.1	1.1	1.2	0.6	13.9	11.9
1962	9.5	6.4	3.2	3.0	2.5	1.9	1.6	0.7	16.7	12.0
1976	12.6	6.8	4.2	4.2	3.1	2.1	2.0	1.1	21.9	14.2
1986	12.1	8.2	4.3	5.4	3.4	2.3	2.3	1.2	22.1	16.0
1991	12.1	8.0	4.3	5.3	3.3	2.0	1.9	1.0	21.6	16.3

	Volume of growing stock									
	Farmer and other private		Forest industry		National forests		Other public		Total	
Year	Soft-wood	Hard-wood	Soft-wood	Hard-wood	Soft-wood	Hard-wood	Soft-wood	Hard-wood	Soft-wood	Hard-wood
					billion cubic feet					
1952	94.8	133.7	77.4	20.3	204.4	13.6	55.2	16.5	431.8	184.1
1962	104.3	152.5	76.1	25.4	213.7	17.2	55.7	20.7	449.8	215.8
1977	125.3	185.8	74.5	32.3	208.1	21.6	59.0	26.5	467.0	266.1
1986	136.6	220.8	72.8	35.3	186.3	25.1	57.3	31.4	452.9	312.6
1992	143.4	242.3	71.0	34.8	185.6	25.6	50.0	33.0	449.9	335.7

Source: Powell, D.S., J.L. Faulkner, D.R. Darr, Z. Zhu and D.W. MacCleery, *Forest Statistics of the United States, 1992*, General Technical Report RM 234 (U.S. Department of Agriculture, Forest Service, Washington, DC, 1993).

Table 7.15 U.S. Production of Timber Products by Major Product, Five-Year Intervals, 1950-1965, and Annually, 1966-1994

Year	Lumber	Plywood & veneer	Pulp products	Fuel	Miscel-laneous	Total
			million cubic feet, roundwood equivalent			
1950	5,905	345	1,500	2,270	770	10,800
1955	5,785	575	2,200	1,745	630	10,970
1960	5,080	705	2,575	1,300	510	10,220
1965	5,665	1,030	3,095	915	567	11,477
1966	5,630	1,035	3,190	845	582	11,522
1967	5,325	1,025	3,195	780	562	11,227
1968	5,545	1,120	3,385	700	101	11,776
1969	5,415	1,050	3,585	620	601	11,681
1970	5,215	1,020	3,840	535	575	11,655
1971	5,390	1,170	3,560	500	538	11,548
1972	5,535	1,300	3,520	475	562	11,932
1973	5,670	1,320	3,755	505	621	12,446
1974	5,095	1,150	4,220	535	635	12,090
1975	4,890	1,170	3,485	570	583	11,153
1976	5,585	1,355	3,810	600	625	12,530
1977	5,950	1,425	3,650	1,000	646	13,196
1978	6,155	1,460	3,745	1,525	619	14,089
1979	6,115	1,370	4,105	2,205	690	15,150
1980	5,305	1,175	4,390	3,105	693	15,228
1981	4,775	1,180	4,125	3,180	646	14,336
1982	5,048	1,119	3,819	3,355	603	14,457
1983	6,044	1,426	4,285	3,235	591	16,141
1984	6,396	1,391	4,681	3,620	590	17,237
1985	6,210	1,426	4,561	3,450	599	16,861
1986	7,077	1,538	4,857	3,096	616	17,768
1987	7,588	1,587	5,137	3,076	633	18,678
1988	7,642	1,538	5,221	3,066	713	18,948
1989	7,440	1,406	5,429	3,041	781	19,121
1990	7,213	1,368	5,353	3,019	805	18,720
1991	6,677	1,226	5,434	3,028	842	18,139
1992	6,864	1,265	5,463	3,044	877	18,389
1993	6,660	1,257	5,391	3,084	864	18,042
1994	6,880	1,268	5,417	3,134	910	18,392

Source: Howard, J.L., *U.S. Timber Production, Trade, Consumption, and Price Statistics, 1965-1994*, Table 4a, p. 12, General Technical Report FPL-GTR-98 (U.S. Department of Agriculture, Forest Service, Forest Products Laboratory, Madison, WI, 1997) and earlier reports in this series.

Note: Miscellaneous includes cooperage logs, poles and pilings, fence posts, hewn ties, round mine timbers, box bolts, excelsior bolts, chemical wood, shingle bolts, log and pulp chip exports, and other products not specified.

Table 7.16 Logging Residues from U.S. Growing Stock and Timber Product Output from U.S. Nongrowing Stock, 1952-1991

Year	Logging residues: Softwood	Logging residues: Hardwood	Output from nongrowing stock: Softwood	Output from nongrowing stock: Hardwood
	% of timber product removals from growing stock		*% of timber supplies*	
1952	9.8	22.2	10.4	20.9
1962	9.6	20.7	10.0	18.5
1970	10.0	19.7	7.0	13.9
1976	8.4	17.1	6.9	14.0
1986	9.0	13.2	11.5	38.5
1991	7.5	12.0	11.9	37.5

Source: Haynes, R.W., D.M. Adams and J.R. Mills, *The 1993 RPA Timber Assessment Update*, Table 7, p. 16, and Table 8, p. 17 (U.S. Department of Agriculture, Forest Service, Washington, DC, 1995).

Notes: Logging residues are lower quality material, such as small stem, chunks, and low-quality stems. Declining amounts of residues reflect increased stumpage prices, improved logging technology, and increased demand for wood products. Timber supplies from nongrowing stock include salvable dead trees, rough and rotten trees, tops and limbs, defective sections of growing stock trees in urban areas, along fence rows, and on forested lands other than timberlands. Output from these sources has been greatly influenced by markets for pulpwood and fuelwood since the late 1970s.

Table 7.17 U.S. Forest Fire Damage and Tree Planting, Ten-Year Intervals, 1930-1950, and Annually, 1951-1996

Year	Forest fire damage	Tree planting	Year	Forest fire damage	Tree planting
	million acres			*million acres*	
1930	52.3	0.14	1973	1.9	1.75
1940	25.9	0.52	1974	2.9	1.60
1950	15.5	0.50	1975	1.8	1.93
1951	10.8	0.45	1976	5.1	1.89
1952	14.2	0.52	1977	3.2	1.98
1953	10.0	0.71	1978	3.9	2.09
1954	8.8	0.81	1979	3.0	2.06
1955	8.1	0.78	1980	5.3	2.27
1956	6.6	0.89	1981	4.8	2.35
1957	3.4	1.14	1982	2.4	2.37
1958	3.3	1.53	1983	5.1	2.45
1959	4.2	2.12	1984	3.0	2.55
1960	4.5	2.14	1985	5.2	2.70
1961	3.0	1.76	1986	3.2	2.75
1962	4.1	1.37	1987	5.0	3.03
1963	7.1	1.33	1988	5.7	3.39
1964	4.2	1.31	1989	3.5	3.02
1965	2.7	1.29	1990	4.6	2.86
1966	4.6	1.28	1991	na	2.56
1967	4.7	1.37	1992	na	2.55
1968	4.2	1.44	1993	na	2.42
1969	6.7	1.43	1994	na	2.78
1970	3.3	1.60	1995	na	2.42
1971	4.3	1.69	1996	na	2.41
1972	2.6	1.68			

Sources: U.S. Department of Agriculture, Forest Service, Wildfire Statistics, unpublished, Washington, DC, annual.

--, *U.S. Forest Planting Report* (USDA, FS, Washington, DC, annual).

Notes: Tree planting refers to acres planted in seedlings and direct seeded. Year refers to fiscal year. na = not available prior to statistical validation. Annual forest fire damage for the years 1991-1996 is estimated to be between 2 and 7 million acres.

Table 7.18 U.S. Forestland Damaged by Insects, 1968-1996

Year	Spruce budworm	Western spruce budworm	Gypsy moth	Mountain pine beetle	Southern pine beetle
			million acres		
1968	1.3	5.3	0.1	na	na
1969	1.2	4.6	0.3	na	na
1970	2.0	4.0	1.0	na	na
1971	1.6	4.8	1.9	na	na
1972	2.8	5.5	1.4	na	na
1973	4.2	4.4	1.8	na	na
1974	10.8	5.5	0.8	na	na
1975	9.2	5.3	0.5	na	na
1976	9.1	5.8	0.9	na	na
1977	10.3	6.5	1.6	na	na
1978	7.7	5.2	1.3	4.0	na
1979	6.6	5.0	0.6	4.4	15.0
1980	6.6	4.0	5.0	4.7	12.1
1981	4.5	5.5	12.9	4.7	0.9
1982	4.2	8.7	8.2	4.2	7.3
1983	6.5	11.0	2.4	3.6	11.4
1984	6.1	10.6	1.0	3.3	na
1985	5.2	12.8	1.7	3.3	15.5
1986	1.0	13.2	2.4	3.5	26.4
1987	0.8	8.0	1.3	2.4	13.8
1988	0.3	6.1	0.7	2.2	7.9
1989	0.2	3.1	3.0	1.6	5.3
1990	0.2	4.6	7.3	0.9	4.2
1991	0.1	7.2	4.2	0.6	10.7
1992	0.1	4.0	3.1	15.8	14.3
1993	0.1	0.5	1.8	0.8	10.4
1994	1.0	0.5	0.9	0.4	5.3
1995	0.8	0.5	1.4	0.6	21.7
1996	0.5	0.3	0.2	0.3	7.3

Sources: U.S. Department of Agriculture, Forest Service, *Forest Insect and Disease Conditions in the United States, 1979-1983* (USDA, FS, Washington, DC, 1985).

--, *Forest Insect and Disease Conditions in the United States* (USDA, FS, Washington, DC, annual from 1986).

Notes: na = not available. Acreage for spruce budworm from 1991 forward includes spruce budworm in Alaska since it is the same species of budworm as in the eastern United States (i.e., it is not the western spruce budworm). Mountain pine beetle data for 1992 includes 15.2 million acres in California not previously reported.

Table 7.19 Conservation Reserve Program Activity, 1986-1996

Event	Number of acres	Average rental payment	Average erosion reduction
	millions	*$/acre/year*	*tons/acre/year*
Signup #1, March 1986[1]	0.75	42.06	26
Signup #2, May 1986	2.77	44.05	27
Signup #3, August 1986[2]	4.70	46.96	25
Signup #4, February 1987[3]	9.48	51.19	19
Signup #5, July 1987	4.44	48.03	17
Signup #6, February 1988[4]	3.38	47.90	18
Signup #7, July 1988	2.60	49.71	17
Signup #8, February 1989[5]	2.46	51.04	14
Signup #9, July-August 1989	3.33	50.99	14
Signup #10, March 1991[6]	0.48	53.66	17
Signup #11, July 1991	1.00	59.37	15
Signup #12, June 1992	1.03	62.98	16
Early-out #1, May 1995	-0.70	58.51	20
Signup #13, September 1995[7]	0.62	53.93	10
Contract Expirations, 1995	-0.13	46.36	26
Early-out #2, 1996	-0.77	57.41	17
Contract Expirations, 1996	-0.96	60.51	22
Net enrollment 1996[8]	32.96	49.20	19

Source: U.S. Department of Agriculture, Economic Research Service, based on CRP contract data.

Notes: [1]Eligible acres includes cropland in land capability classes II-V eroding at least three times greater than the tolerance rate, or any cropland in land capability classes VI-VIII. [2]Eligible acres expanded to include cropland in land capability classes II-V eroding at least two times the tolerance rate and having gully erosion. [3]Eligible acres expanded to include cropland eroding above the tolerance rate with an erodibility index of 8 or greater. [4]Eligible acres expanded to include cropland in land capability classes II-V eroding at least two times the tolerance rate if planted in trees. Eligibility also extended to cropland areas 66-99 feet wide adjacent to permanent waterbodies for placement of filter strip. [5]Eligible acres expanded to include cropped wetlands and cropland areas subject to scour erosion. [6]Eligible acres expanded to include cropland devoted to easement practices, cropland in state water quality areas, cropland in conservation priority areas, and cropland within established wellhead protection areas. Farmed wetlands, even if otherwise eligible, were ineligible for enrollment. [7]Eligible acres included fields with an average erodibility index greater than or equal to 8, cropland areas with evidence of scour erosion caused by out-of-bank water flows and flooding occurring in at least one out of 10 years, wellhead protection areas identified by EPA, any cropland determined suitable for riparian buffer/filter by NRCS, small farmed wetlands contained in and part of a field that was otherwise eligible, or any cropland located in the Chesapeake Bay region watershed, the Great Lakes region watershed, the Long Island Sound watershed, other areas designated as conservation priority areas in CRP signup #12, and newly approved state priority areas. [8]Net after subtracting 1.5 million acres terminated by producers prior to 1995 early-out.

Pollution Prevention

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326

Table 8.1 U.S. Municipal Solid Waste Trends, 1960-1996

Year	Gross discards	Recovery for recycling	Recovery for composting	Net discards	Combustion	Discards to landfills	Per capita waste generation
			million tons				lbs/day
1960	88.12	5.61	**	82.51	27.00	55.51	2.68
1970	121.06	8.02	**	113.04	25.10	87.94	3.25
1980	151.64	14.52	**	137.12	13.70	123.42	3.66
1990	205.21	29.38	4.20	171.63	31.90	139.73	4.51
1996	209.66	46.01	11.32	152.33	36.09	116.24	4.33

Source: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. *Characterization of Municipal Solid Waste in the United States: 1997 Update*, Table 34, p. 119 and Table B-2, p. 162 (EPA, Washington, DC, 1998).

Note: **Negligible (less than 500,000 tons).

Table 8.2 U.S. Municipal Solid Waste Trends by Waste Type, 1960-1996

	Paper		Glass		Metals*		Aluminum		Plastics		Rubber and leather	
Year	Generation	Recovery	Generation	Recovery	Generation	Recovery	Generation	Recovery	Generation	Recovery	Generation	Recovery
						million tons						
1960	29.99	5.08	6.72	0.10	10.48	0.05	0.34	**	0.39	**	1.84	0.33
1970	44.31	6.77	12.74	0.16	13.03	0.48	0.80	0.01	2.90	**	2.97	0.25
1980	55.16	11.74	15.13	0.75	13.78	0.91	1.73	0.31	6.83	0.02	4.20	0.13
1990	72.73	20.23	13.10	2.62	13.74	3.31	2.81	1.01	17.13	0.37	5.79	0.37
1996	79.93	32.61	12.35	3.17	13.09	5.34	2.98	1.02	19.76	1.06	6.20	0.59

	Textiles		Wood		Other		Food		Yard		Miscellaneous	
Year	Generation	Recovery	Generation	Recovery	Generation	Recovery	Generation	Recovery	Generation	Recovery	Generation	Recovery
						million tons						
1960	1.76	0.05	3.03	**	0.07	**	12.20	**	20.00	**	1.30	**
1970	2.04	0.06	3.72	**	0.77	0.30	12.80	**	23.20	**	1.78	**
1980	2.53	0.16	7.01	**	2.52	0.50	20.00	**	27.50	**	2.25	**
1990	5.81	0.67	12.21	0.13	3.19	0.68	13.20	**	35.00	4.20	2.90	**
1996	7.76	0.95	10.84	0.49	3.69	0.78	21.90	0.52	29.75	10.80	3.20	**

Source: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. *Characterization of Municipal Solid Waste in the United States: 1997 Update*, Table 1, p. 27 and Table 2, p. 28 (EPA, Washington, DC, 1998).

Notes: *Ferrous and other nonferrous metals except aluminum. **Negligible (less than 5,000 tons). Other includes electrolytes in batteries and disposable paper diapers.

Table 8.3 U.S. Inventory of Low-level Nuclear Waste, 1965-1996, High-level Nuclear Waste, 1980-1996, and Spent Nuclear Fuel, 1980-1996

	Commercial low-level nuclear waste shipped for disposal				
Year	Volume *million cubic meters*	Radioactivity *million curies*	Year	Volume *million cubic meters*	Radioactivity *million curies*
1965	0.034	0.273	1981	0.852	4.483
1966	0.049	0.355	1982	0.929	4.568
1967	0.071	0.428	1983	1.007	4.732
1968	0.091	0.529	1984	1.083	4.954
1969	0.112	0.687	1985	1.160	5.282
1970	0.138	0.855	1986	1.213	5.059
1971	0.169	2.000	1987	1.265	4.924
1972	0.208	2.287	1988	1.306	4.793
1973	0.255	2.732	1989	1.352	5.284
1974	0.309	2.754	1990	1.384	4.979
1975	0.367	3.040	1991	1.423	5.272
1976	0.442	3.268	1992	1.472	5.708
1977	0.514	3.765	1993	1.496	5.709
1978	0.593	4.383	1994	1.519	5.841
1979	0.676	4.539	1995	1.538	5.376
1980	0.768	4.547	1996	1.558	5.020

	High-level nuclear waste at DOE/defense and commercial sites			Spent nuclear fuel at commercial sites	
Year	Volume *thousand cubic meters*	Radioactivity *million curies*	Year	Volume *metric tons initial heavy metal*	Radioactivity *million curies*
1980	329.7	1,362.6	1980	6,558	10,137
1981	339.3	1,628.5	1981	7,692	10,552
1982	342.0	1,369.4	1982	8,090	10,400
1983	352.7	1,299.7	1983	9,952	12,088
1984	363.5	1,356.2	1984	11,291	13,222
1985	357.1	1,459.5	1985	12,684	14,228
1986	365.9	1,419.0	1986	14,139	15,308
1987	381.4	1,303.1	1987	15,844	17,292
1988	384.9	1,206.7	1988	17,497	18,207
1989	381.1	1,113.9	1989	19,410	20,209
1990	398.5	1,050.8	1990	21,547	22,910
1991	396.5	1,007.4	1991	23,406	22,825
1992	398.3	1,081.2	1992	25,697	26,136
1993	403.5	1,045.3	1993	27,929	27,516
1994	378.4	958.8	1994	29,811	26,061
1995	373.4	915.4	1995	32,022	na
1996	371.9	864.8	1996	34,300	na

Source: U.S. Department of Energy, Office of Environmental Management, *Integrated Data Base Report - 1995: U.S. Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics* (DOE, EM, Washington, DC, December 1996).

Notes: na = not available. Volumes and radioactivity are cumulative. Radioactivity added each year is decayed. Data for 1996 are projections.

Table 8.4 U.S. Superfund Inventory and NPL Sites, 1980-1996

Year	Superfund	NPL
	number of sites, cumulative	
1980	8,689	0
1981	13,893	0
1982	14,697	160
1983	16,023	551
1984	18,378	547
1985	22,238	864
1986	24,940	906
1987	27,274	967
1988	29,809	1,195
1989	31,650	1,254
1990	33,371	1,236
1991	35,108	1,245
1992	36,869	1,275
1993	38,169	1,321
1994	39,099	1,360
1995	15,622	1,374
1996	12,781	1,210

Source: U.S. Environmental Protection Agency, unpublished, Washington, DC, 1997.

Notes: NPL = National Priorities List. The 1995 data reflect the removal of over 24,000 sites from the Superfund inventory as part of EPA's Brownfields initiative.

Table 8.5 U.S. Production of Selected Ozone-depleting Chemicals, 1958-1994

Year	CFC-11	CFC-12	HCFC-22	CFC-113	CH_3CCl
		thousand metric tons of CFC-11 equivalent			
1958	22.9	59.6	0.76	0.0	0.0
1959	27.4	71.3	0.83	0.0	0.0
1960	32.8	75.5	0.91	1.6	0.0
1961	41.2	78.7	1.03	2.4	0.0
1962	56.6	94.3	1.12	3.2	0.0
1963	63.6	98.6	1.23	3.6	0.0
1964	67.4	103.4	1.34	4.3	0.0
1965	77.3	123.1	1.46	5.1	0.0
1966	77.3	129.9	1.59	5.8	0.0
1967	82.7	140.5	1.78	7.6	13.7
1968	92.7	147.7	1.96	9.1	14.6
1969	108.2	166.8	2.14	10.9	15.6
1970	110.9	170.3	2.28	13.1	16.6
1971	117.0	176.7	2.55	15.6	17.4
1972	135.9	199.2	2.80	18.2	18.2
1973	151.4	221.7	3.09	21.4	19.0
1974	154.7	221.1	3.21	23.2	19.9
1975	122.3	178.3	2.99	24.8	20.8
1976	116.2	178.3	3.85	29.7	24.8
1977	96.4	162.3	4.07	36.2	28.8
1978	87.9	148.4	4.67	41.0	29.2
1979	75.8	133.3	4.78	47.0	32.5
1980	71.7	133.8	5.16	36.7	31.4
1981	73.8	147.6	5.71	38.6	27.9
1982	63.7	117.0	3.95	40.0	27.0
1983	73.1	134.3	5.36	42.2	26.6
1984	83.9	152.7	5.76	60.2	30.6
1985	79.7	136.9	5.34	65.8	39.4
1986	91.6	146.2	6.15	69.2	29.6
1987	89.7	151.9	6.23	72.3	31.5
1988	113.0	187.7	7.54	79.2	32.8
1989	83.3	141.2	7.24	80.4	35.5
1990	61.0	94.6	6.94	55.9	36.4
1991	44.9	71.3	7.13	47.2	29.2
1992	45.5	73.9	7.48	28.5	31.4
1993	32.8	83.7	6.61	11.4	20.5
1994	na	57.5	6.93	na	na

Source: U.S. International Trade Commission, *Synthetic Organic Chemicals, United States Production and Sales* (GPO, Washington, DC, annual).

Notes: CFC-11 = Trichlorofluoromethane. CFC-12 = Dichlorodifluoromethane. HCFC-22 = Chlorodifluoromethane. CFC-113 = Trichlorotrifluoroethane. CH_3CCL_3 = Trichloroethane or methyl chloroform. This series ended after the publication of the 1994 data.

Table 8.6 U.S. Toxics Release Inventory Releases and Transfers, 1988 and 1993-1995

	1988	1993	1994	1995	1988-1995 change
		billion pounds			*percent*
Releases					
Air Emissions	2.177	1.317	1.264	1.173	-46.1
Fugitive air	0.680	0.376	0.350	0.302	-55.6
Point source air	1.497	0.941	0.914	0.870	-41.9
Surface water	0.164	0.195	0.040	0.036	-78.2
Underground injection	0.162	0.113	0.114	0.137	-15.6
On-site land releases	0.459	0.268	0.283	0.265	-42.2
Total releases	2.962	1.894	1.701	1.610	-45.6
Transfers					
To recycling	na	1.937	2.164	2.141	na
To energy-recovery	na	0.445	0.455	0.486	na
To treatment	0.396	0.208	0.217	0.235	-36.3
To POTWs	0.255	0.163	0.158	0.155	-39.3
To disposal	0.386	0.251	0.259	0.255	-34.0
To other	0.043	0.002	0.003	0.002	na
Total transfers	1.053	3.006	3.263	3.274	na
Total releases and transfers	4.015	4.900	4.964	4.884	na

Source: U.S. Environmental Protection Agency, Office of Pollution Prevention and Toxics, *1995 Toxics Release Inventory: Public Data Release* (EPA, Washington, DC, 1997).

Notes: Data do not include delisted chemicals, chemicals added in 1990, 1991, 1994, and 1995, and aluminum oxide, ammonia, hydrochloric acid, and sulfuric acid. Transfers for recycling or energy recovery were not required to be reported in 1988. For 1993, 1994, and 1995, other includes transfers reported with no waste management codes or invalid codes. For 1988, other includes transfers reported with no waste management codes, invalid codes, or codes not required to be reported in 1988. na = not available.

Table 8.7 U.S. Toxics Release Inventory Releases and Transfers by Industry, 1988 and 1993-1995

Industry	1988	1993	1994	1995	1988-1995 change
			million pounds		*percent*
Food	7.289	7.528	6.160	5.281	-27.5
Tobacco	0.342	0.137	0.135	0.095	-72.2
Textile	34.154	17.450	15.773	14.990	-56.1
Apparel	0.922	1.003	1.311	1.232	33.6
Lumber	31.050	29.264	32.345	29.497	-5.0
Furniture	61.363	54.276	51.525	40.712	-33.7
Paper	201.459	148.849	180.646	176.176	-12.6
Printing	60.694	36.148	34.313	31.375	-48.3
Chemical	979.850	679.468	495.871	492.005	-49.8
Petroleum	67.649	49.334	42.535	40.190	-40.6
Plastics	146.535	119.295	112.865	100.928	-31.1
Leather	11.928	4.473	3.620	2.649	-77.8
Stone clay glass	23.923	12.161	10.836	12.648	-47.1
Primary metals	471.664	281.310	273.635	291.697	-38.2
Fabr. metals	130.537	88.873	85.551	78.245	-40.1
Machinery	59.463	26.566	23.576	19.293	-67.6
Electrical equip	115.408	32.723	28.850	23.445	-79.7
Transportation	188.630	121.900	118.900	104.852	-44.4
Measure photo	47.210	20.255	13.540	12.202	-74.2
Miscellaneous	28.471	15.279	13.828	11.188	-60.7
Multiple codes	283.311	131.240	137.651	114.132	-59.7
No codes	10.499	18.029	16.394	7.617	-27.5
Total	2,962.349	1,893.560	1,700.861	1,610.448	-45.6

Source: U.S. Environmental Protection Agency, Office of Pollution Prevention and Toxics, *1995 Toxics Release Inventory: Public Data Release* (EPA, Washington, DC, 1997).

Table 8.8 U.S. Toxics Release Inventory Releases and Transfers by State, 1988 and 1993-1995

State	1988	1993	1994	1995	1988-1995 change
			million pounds		*percent*
Alabama	103.599	90.151	84.093	88.803	-14.3
Alaska	3.713	2.104	1.095	2.158	-41.9
Arizona	65.699	11.813	30.504	33.525	-49.0
Arkansas	35.988	23.853	27.568	22.863	-36.5
California	90.479	41.417	33.852	26.460	-70.8
Colorado	13.222	3.958	3.726	3.190	-75.9
Connecticut	32.536	12.393	10.062	7.201	-77.9
Delaware	6.925	3.914	3.642	2.822	-59.2
District of Columbia	<0.001	0.000	0.029	0.030	5,843.0
Florida	59.389	45.794	70.223	50.666	-14.7

See next page for continuation of table

Table 8.8 U.S. Toxics Release Inventory Releases and Transfers by State, 1988 and 1993-1995 (continued)

State	1988	1993	1994	1995	1988-1995 change
			million pounds		*percent*
Georgia	67.892	36.394	41.140	36.503	-46.2
Hawaii	0.834	0.499	0.514	0.398	-52.3
Idaho	7.283	1.870	2.393	2.625	-64.0
Illinois	107.659	69.935	71.707	67.396	-37.4
Indiana	160.767	78.980	65.019	62.657	-61.0
Iowa	38.598	22.572	21.081	19.184	-50.3
Kansas	28.564	16.636	15.843	14.582	-49.0
Kentucky	49.698	30.870	29.578	28.013	-43.6
Louisiana	241.889	263.611	113.098	119.733	-50.5
Maine	14.673	6.076	6.055	5.821	-60.3
Maryland	17.996	10.333	10.611	10.108	-43.8
Massachusetts	26.065	10.045	8.581	6.937	-73.4
Michigan	94.915	71.910	75.924	54.148	-43.0
Minnesota	54.343	22.078	19.589	16.771	-69.1
Mississippi	54.595	42.546	41.332	38.178	-30.1
Missouri	85.229	47.557	44.176	39.813	-53.3
Montana	35.587	44.485	46.348	42.615	19.7
Nebraska	13.509	9.498	7.989	7.303	-45.9
Nevada	2.288	2.946	3.002	3.175	38.8
New Hampshire	12.279	3.185	2.235	1.840	-85.0
New Jersey	36.331	14.070	12.541	10.882	-70.0
New Mexico	30.246	22.938	17.132	17.869	-40.9
New York	87.704	33.468	29.394	25.618	-70.8
North Carolina	121.477	76.501	77.888	69.164	-43.1
North Dakota	1.130	0.918	0.977	1.183	4.7
Ohio	157.020	95.506	90.806	94.078	-40.1
Oklahoma	28.263	14.964	12.719	12.862	-54.5
Oregon	17.836	13.985	15.833	17.746	-0.5
Pennsylvania	97.147	43.982	44.629	40.237	-58.6
Puerto Rico	12.669	10.453	9.073	8.370	-33.9
Rhode Island	6.321	3.387	3.026	2.556	-59.6
South Carolina	60.584	44.670	42.442	44.180	-27.1
South Dakota	2.312	1.891	1.998	1.757	-24.0
Tennessee	115.218	95.015	87.016	88.368	-23.3
Texas	302.813	197.101	187.319	188.296	-37.8
Utah	123.311	94.202	65.671	68.622	-44.4
Vermont	1.594	0.616	0.607	0.511	-68.0
Virgin Islands	1.848	1.579	0.961	1.186	-35.8
Virginia	109.750	43.669	42.088	39.248	-64.2
Washington	25.877	16.707	19.863	20.959	-19.0
West Virginia	31.331	18.493	17.898	15.861	-49.4
Wisconsin	48.633	29.233	29.095	24.266	-50.1
Wyoming	16.739	0.794	0.875	1.110	-93.4
Total	2,962.349	1,893.560	1,700.861	1,610.448	-45.6

Source: U.S. Environmental Protection Agency, Office of Pollution Prevention and Toxics, *1995 Toxics Release Inventory: Public Data Release* (EPA, Washington, DC, 1997).

Table 8.9 Contaminant Levels in Herring Gull Eggs from Great Lakes Colonies, 1974-1996

Year	Lake Superior				
	DDE	Dieldrin	Mirex	HCB	PCBs
	parts per million in whole egg samples, wet weight				
1974	16.59	0.51	1.04	0.26	62.08
1975	23.10	0.38	0.96	0.18	76.24
1976	na	na	na	na	na
1977	11.92	0.38	0.33	0.24	55.22
1978	9.64	0.39	0.28	0.12	41.57
1979	6.83	0.60	0.26	0.14	58.74
1980	3.67	0.34	0.13	0.08	25.58
1981	5.74	0.44	0.14	0.12	33.84
1982	6.29	0.39	0.37	0.08	34.74
1983	3.17	0.33	0.15	0.05	21.42
1984	2.94	0.36	0.12	0.05	16.91
1985	3.13	0.32	0.11	0.05	15.89
1986	3.22	0.34	0.11	0.05	14.10
1987	2.52	0.20	0.10	0.04	12.35
1988	2.94	0.34	0.06	0.05	13.43
1989	2.50	0.34	0.07	0.05	15.09
1990	2.64	0.30	0.06	0.03	11.62
1991	3.60	0.27	0.07	0.04	14.09
1992	3.69	0.40	0.07	0.06	13.95
1993	4.09	0.19	0.08	0.03	15.70
1994	2.39	0.15	0.10	0.03	12.30
1995	2.49	0.11	0.08	0.02	11.15
1996	2.88	0.15	0.08	0.04	12.60

See next page for continuation of table.

Table 8.9 Contaminant Levels in Herring Gull Eggs from Great Lakes Colonies, 1974-1996 (continued)

	Lake Michigan				
Year	DDE	Dieldrin	Mirex	HCB	PCBs
	parts per million in whole egg samples, wet weight				
1974	na	na	na	na	na
1975	na	na	na	na	na
1976	33.40	0.82	0.36	0.14	118.42
1977	29.25	0.68	0.14	0.24	107.80
1978	22.36	0.87	0.21	0.12	90.74
1979	na	na	na	na	na
1980	12.17	0.70	0.10	0.09	57.83
1981	na	na	na	na	na
1982	15.86	0.81	0.09	0.09	65.41
1983	6.46	0.61	0.05	0.05	30.27
1984	7.85	0.53	0.09	0.06	31.47
1985	6.98	0.47	0.12	0.05	31.94
1986	7.48	0.38	0.07	0.07	27.25
1987	3.95	0.33	0.06	0.04	16.58
1988	5.04	0.55	0.03	0.04	19.14
1989	4.74	0.54	0.04	0.04	21.00
1990	8.12	0.54	0.06	0.05	32.19
1991	10.52	0.34	0.12	0.05	31.27
1992	6.71	0.41	0.04	0.04	20.25
1993	na	na	na	na	na
1994	10.10	0.34	0.08	0.05	32.85
1995	6.38	0.19	0.05	0.03	23.30
1996	6.10	0.21	0.08	0.04	22.70

See next page for continuation of table.

Table 8.9 Contaminant Levels in Herring Gull Eggs from Great Lakes Colonies, 1974-1996 (continued)

	Lake Huron				
Year	DDE	Dieldrin	Mirex	HCB	PCBs
	parts per million in whole egg samples, wet weight				
1974	17.40	0.50	1.34	0.38	71.01
1975	14.03	0.36	0.51	0.21	42.67
1976	na	na	na	na	na
1977	16.17	0.54	0.44	0.36	70.28
1978	6.53	0.22	0.21	0.11	32.38
1979	2.30	0.30	0.19	0.10	28.66
1980	2.71	0.24	0.11	0.07	20.41
1981	3.82	0.24	0.26	0.07	25.39
1982	4.43	0.28	0.48	0.08	34.29
1983	2.74	0.22	0.15	0.05	18.28
1984	2.56	0.22	0.34	0.07	19.95
1985	2.77	0.30	0.22	0.06	16.90
1986	2.05	0.21	0.12	0.05	12.00
1987	1.32	0.22	0.08	0.02	8.33
1988	1.40	0.22	0.07	0.04	8.83
1989	1.57	0.20	0.09	0.03	10.19
1990	1.86	0.14	0.11	0.03	11.34
1991	1.97	0.16	0.11	0.03	10.00
1992	2.36	0.16	0.05	0.05	10.20
1993	3.18	0.19	0.06	0.03	10.95
1994	2.19	0.13	0.10	0.03	11.25
1995	1.60	0.10	0.06	0.03	8.95
1996	2.01	0.13	0.14	0.08	10.05

See next page for continuation of table.

Table 8.9 Contaminant Levels in Herring Gull Eggs from Great Lakes Colonies, 1974-1996 (continued)

	Lake Erie				
Year	DDE	Dieldrin	Mirex	HCB	PCBs
	parts per million in whole egg samples, wet weight				
1974	7.13	0.35	0.64	0.29	72.46
1975	7.41	0.33	0.32	0.19	62.30
1976	na	na	na	na	na
1977	7.49	0.40	0.45	0.37	68.70
1978	4.29	0.24	0.20	0.09	44.43
1979	3.10	0.25	0.17	0.11	48.44
1980	2.98	0.21	0.18	0.09	46.38
1981	3.90	0.22	0.25	0.09	56.49
1982	3.07	0.25	0.13	0.08	58.89
1983	2.39	0.20	0.17	0.05	37.31
1984	3.23	0.33	0.22	0.06	46.20
1985	2.83	0.19	0.14	0.06	38.41
1986	2.77	0.23	0.14	0.06	33.35
1987	1.77	0.14	0.12	0.03	23.16
1988	2.07	0.17	0.10	0.05	27.50
1989	2.69	0.17	0.18	0.05	39.21
1990	2.01	0.10	0.11	0.03	30.09
1991	2.12	0.08	0.07	0.02	26.55
1992	1.68	0.13	0.05	0.04	24.45
1993	1.49	0.10	0.07	0.02	21.70
1994	1.55	0.08	0.08	0.03	22.90
1995	1.21	0.08	0.07	0.03	23.55
1996	1.25	0.06	0.09	0.03	15.50

See next page for continuation of table.

Table 8.9 Contaminant Levels in Herring Gull Eggs from Great Lakes Colonies, 1974-1996 (continued)

	Lake Ontario				
Year	DDE	Dieldrin	Mirex	HCB	PCBs
	parts per million in whole egg samples, wet weight				
1974	22.30	0.47	6.99	0.58	152.37
1975	22.80	0.29	4.70	0.33	143.11
1976	na	na	na	na	na
1977	14.88	0.39	2.48	0.80	102.50
1978	10.65	0.26	1.59	0.32	72.43
1979	8.94	0.21	1.89	0.21	69.60
1980	7.62	0.19	1.65	0.17	56.43
1981	11.00	0.28	2.67	0.24	78.90
1982	10.04	0.28	3.05	0.16	62.90
1983	4.78	0.18	1.43	0.08	42.59
1984	6.26	0.21	1.87	0.12	51.11
1985	6.02	0.15	1.47	0.07	35.58
1986	4.41	0.16	1.10	0.07	27.86
1987	2.60	0.13	0.68	0.04	16.48
1988	4.25	0.15	0.82	0.07	23.53
1989	5.28	0.22	1.15	0.07	32.45
1990	3.36	0.10	0.64	0.03	18.44
1991	3.53	0.14	0.58	0.03	17.05
1992	5.01	0.13	0.77	0.05	21.20
1993	5.27	0.13	0.82	0.04	21.05
1994	3.83	0.13	0.80	0.04	19.70
1995	2.23	0.05	0.57	0.02	13.60
1996	3.03	0.10	0.68	0.04	16.15

Source: Environment Canada, Canadian Wildlife Service, Canada Centre for Inland Waters, Organochlorine Contaminant Concentrations in Herring Gull Eggs from Great Lakes Colonies, unpublished, Burlington, ON, 1996.

Notes: DDE = Derivative of Dichloro-diphenyl-trichloro ethane (DDT). HCB = Hexachlorobenzene. PCBs = Polychlorinated biphenyls. na = not available. Data for Lake Michigan for 1996 are based on only one count per sampling site.

Table 8.10 Pesticide Residues in U.S. Domestic Surveillance Food Samples by Commodity Group, 1978-1996

	Commodity group						
Year	Grains & grain products	Milk, dairy products & eggs	Fish, shellfish & meats	Fruits	Vegetables	Other	Total
	percentage of samples without residues found						
1978	46	57	20	52	66	58	53
1979	46	53	19	42	65	53	51
1980	48	64	29	47	60	64	54
1981	57	68	23	44	63	66	56
1982	58	66	28	51	64	68	59
1983	58	68	39	48	59	69	57
1984	46	69	25	62	67	69	63
1985	48	78	35	64	66	78	65
1986	40	79	32	43	61	52	56
1987	43	76	27	50	63	63	58
1988	51	81	28	49	65	72	60
1989	56	87	35	56	68	80	65
1990	54	91	32	51	62	79	60
1991	58	78	58	49	68	81	64
1992	61	94	48	51	69	81	65
1993	66	94	53	70	39	83	64
1994	61	93	59	44	66	88	63
1995	33	100	80	48	48	80	54
1996	53	97	62	46	64	75	64

Source: Food and Drug Administration, *Pesticide Program Residues Monitoring 1996* (Washington, DC: FDA, January 1998), and earlier annual reports.

Notes: Domestic food samples are collected as close as possible to the point of production. Fresh produce is analyzed as the unwashed whole, raw commodity. Although a percentage of samples contain pesticide residues, the percent of samples with over-tolerance residues (as set by EPA) is low. Between 1973 and 1986, 3 percent of samples were classed as violative; between 1987 and 1996 less than 1 percent were violative.

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Energy

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Table 9.1 Proved Reserves of Liquid and Gaseous Hydrocarbons in the United States, 1977-1996

Year	Crude oil *billion barrels*	Natural gas *trillion cubic feet*	Natural gas liquids *billion barrels*
1977	31.8	207.4	na
1978	31.4	208.0	6.8
1979	29.8	201.0	6.6
1980	29.8	199.0	6.7
1981	29.4	201.7	7.1
1982	27.9	201.5	7.2
1983	27.7	200.5	7.9
1984	28.4	197.5	7.6
1985	28.4	193.4	7.9
1986	26.9	191.6	8.2
1987	27.3	187.2	8.1
1988	26.8	168.0	8.2
1989	26.5	167.1	7.8
1990	26.3	169.3	7.6
1991	24.7	167.1	7.5
1992	23.7	165.0	7.5
1993	23.0	162.4	7.2
1994	22.5	163.8	7.2
1995	22.4	165.1	7.4
1996	22.0	166.5	7.8

Source: U.S. Department of Energy, Energy Information Administration, *U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves, 1996 Annual Report*, Table 1, p. 3 and Appendix D, Historical Reserves Statistics, DOE/EIA 0216(96) (GPO, Washington, DC, 1997).

Table 9.2 U.S. Energy Production by Source, 1960-1996

Year	Coal	Crude oil & NGPL	Natural gas	Hydroelectric power	Nuclear	Geothermal & other renewables	Total
				quadrillion Btu			
1960	10.82	16.40	12.66	1.61	0.01	<0.01	41.49
1961	10.45	16.76	13.10	1.66	0.02	<0.01	41.99
1962	10.90	17.12	13.72	1.82	0.03	<0.01	43.58
1963	11.85	17.68	14.51	1.77	0.04	<0.01	45.85
1964	12.52	17.97	15.30	1.89	0.04	<0.01	47.72
1965	13.06	18.40	15.78	2.06	0.04	<0.01	49.34
1966	13.47	19.56	17.01	2.06	0.06	<0.01	52.17
1967	13.83	20.83	17.94	2.35	0.09	0.01	55.04
1968	13.61	21.63	19.07	2.35	0.14	0.01	56.81
1969	13.86	21.98	20.45	2.65	0.15	0.01	59.10
1970	14.61	22.91	21.67	2.63	0.24	0.01	62.07
1971	13.19	22.58	22.28	2.82	0.41	0.01	61.29
1972	14.09	22.64	22.21	2.86	0.58	0.03	62.42
1973	13.99	22.06	22.19	2.86	0.91	0.04	62.06
1974	14.07	21.05	21.21	3.18	1.27	0.05	60.84
1975	14.99	20.10	19.64	3.15	1.90	0.07	59.86
1976	15.65	19.59	19.48	2.98	2.11	0.08	59.89
1977	15.76	19.78	19.57	2.33	2.70	0.09	60.22
1978	14.91	20.68	19.49	2.94	3.02	0.06	61.10
1979	17.54	20.39	20.08	2.93	2.78	0.09	63.80
1980	18.60	20.50	19.91	2.90	2.74	0.11	64.76
1981	18.38	20.45	19.70	2.76	3.01	0.12	64.42
1982	18.64	20.50	18.32	3.27	3.13	0.11	63.96
1983	17.25	20.58	16.50	3.53	3.20	0.13	61.28
1984	19.72	21.12	18.01	3.39	3.55	0.17	65.96
1985	19.33	21.23	16.98	2.97	4.15	0.21	64.87
1986	19.51	20.53	16.54	3.07	4.47	0.23	64.35
1987	20.14	19.89	17.14	2.63	4.91	0.25	64.95
1988	20.74	19.54	17.60	2.33	5.66	0.24	66.10
1989	21.36	18.28	17.85	2.77	5.68	0.22	66.13
1990	22.46	17.75	18.36	2.98	6.16	3.06	70.78
1991	21.59	18.01	18.23	2.94	6.58	3.08	70.42
1992	21.59	17.59	18.38	2.57	6.61	3.24	69.96
1993	20.22	16.90	18.58	2.84	6.52	3.25	68.32
1994	22.07	16.49	19.35	2.64	6.84	3.30	70.69
1995	21.98	16.33	19.10	3.18	7.18	3.38	71.12
1996	22.65	16.27	19.53	3.56	7.17	3.47	72.61

Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1996*, Table 1.2, p. 7, DOE/EIA-0384(96) (GPO, Washington, DC, 1997).

Notes: NGPL = Natural gas plant liquids. Hydroelectric power includes hydroelectric pumped storage which represents total pumped storage facility production minus energy used for pumping. Other renewables include electricity produced from wood, waste, wind, photovoltaic, and solar thermal sources. There is a discontinuity in this time series between 1989 and 1990 due to expanded coverage of nonelectric utility use of renewable energy beginning in 1990. Previous-year data may have been revised. Current-year data are preliminary and may be revised in future publications.

Table 9.3 U.S. Coal Production by Rank, Mining Method, and Location, 1960-1996

	Rank				Mining method		Location		
Year	Bituminous	Subbituminous	Lignite	Anthracite	Underground	Surface	West	East	Total
	million tons								
1960	415.5	i	i	18.8	292.6	141.7	21.3	413.0	434.3
1961	403.0	i	i	17.4	279.6	140.9	21.8	398.6	420.4
1962	422.1	i	i	16.9	287.9	151.1	21.4	417.6	439.0
1963	458.9	i	i	18.3	309.0	168.2	23.7	453.5	477.2
1964	487.0	i	i	17.2	327.7	176.5	25.7	478.5	504.2
1965	512.1	i	i	14.9	338.0	189.0	27.4	499.5	527.0
1966	533.9	i	i	12.9	342.6	204.2	28.0	518.8	546.8
1967	552.6	i	i	12.3	352.4	212.5	28.9	536.0	564.9
1968	545.2	i	i	11.5	346.6	210.1	29.7	527.0	556.7
1969	547.2	8.3	5.0	10.5	349.2	221.7	33.3	537.7	571.0
1970	578.5	16.4	8.0	9.7	340.5	272.1	44.9	567.8	612.7
1971	521.3	22.2	8.7	8.7	277.2	283.7	51.0	509.9	560.9
1972	556.8	27.5	11.0	7.1	305.0	297.4	64.3	538.2	602.5
1973	543.5	33.9	14.3	6.8	300.1	298.5	76.4	522.1	598.6
1974	545.7	42.2	15.5	6.6	278.0	332.1	91.9	518.1	610.0
1975	577.5	51.1	19.8	6.2	293.5	361.2	110.9	543.7	654.6
1976	588.4	64.8	25.5	6.2	295.5	389.4	136.1	548.8	684.9
1977	581.0	82.1	28.2	5.9	266.6	430.6	163.9	533.3	697.2
1978	534.0	96.8	34.4	5.0	242.8	427.4	183.0	487.2	670.2
1979	612.3	121.5	42.5	4.8	320.9	460.2	221.4	559.7	781.1
1980	628.8	147.7	47.2	6.1	337.5	492.2	251.0	578.7	829.7
1981	608.0	159.7	50.7	5.4	316.5	507.3	269.9	553.9	823.8
1982	620.2	160.9	52.4	4.6	339.2	499.0	273.9	564.3	838.1
1983	568.6	151.0	58.3	4.1	300.4	481.7	274.7	507.4	782.1
1984	649.5	179.2	63.1	4.2	352.1	543.9	308.3	587.6	895.9
1985	613.9	192.7	72.4	4.7	350.8	532.8	324.9	558.7	883.6
1986	620.1	189.6	76.4	4.3	360.4	529.9	325.9	564.4	890.3
1987	636.6	200.2	78.4	3.6	372.9	545.9	336.8	581.9	918.8
1988	638.1	223.5	85.1	3.6	382.2	568.1	370.7	579.6	950.3
1989	659.8	231.2	86.4	3.3	393.8	586.9	381.7	599.0	980.7
1990	693.2	244.3	88.1	3.5	424.5	604.5	398.9	630.2	1,029.1
1991	650.7	255.3	86.5	3.4	407.2	588.8	404.7	591.3	996.0
1992	651.9	252.1	90.1	3.5	407.2	590.3	409.0	588.6	997.5
1993	576.7	274.9	89.5	4.3	351.1	594.4	429.2	516.2	945.4
1994	640.3	300.5	88.1	4.6	399.1	634.4	467.2	566.3	1,033.5
1995	613.8	328.0	86.5	4.7	396.2	636.7	488.7	544.2	1,033.0
1996	644.9	322.2	91.6	4.2	407.7	655.2	505.1	557.8	1,062.9

Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1996*, Table 7.2, p. 209, DOE/EIA-0384(96) (GPO, Washington, DC, 1997).

Notes: i = included in bituminous coal. Location refers to east and west of the Mississippi River. Totals may not agree with sum of components due to independent rounding. Previous year data may have been revised. Current year data are estimates and may be revised in future publications.

Table 9.4 U.S. Petroleum Production and Imports, 1942-1996

Year	Production: Crude oil	Production: NGPL	Production: Total	Total imports
	million barrels per day			
1942	3.80	0.23	4.03	0.03
1943	4.12	0.24	4.37	0.38
1944	4.60	0.27	4.97	0.12
1945	4.69	0.31	5.00	0.20
1946	4.75	0.32	5.07	0.24
1947	5.09	0.36	5.45	0.27
1948	5.53	0.40	5.94	0.35
1949	5.05	0.43	5.48	0.65
1950	5.41	0.50	5.91	0.85
1951	6.16	0.56	6.72	0.84
1952	6.27	0.61	6.87	0.95
1953	6.46	0.65	7.11	1.03
1954	6.34	0.69	7.03	1.05
1955	6.81	0.77	7.58	1.25
1956	7.15	0.80	7.95	1.44
1957	7.17	0.81	7.98	1.57
1958	6.71	0.81	7.52	1.70
1959	7.05	0.88	7.93	1.78
1960	7.04	0.93	7.96	1.81
1961	7.18	0.99	8.17	1.92
1962	7.33	1.02	8.35	2.08
1963	7.54	1.10	8.64	2.12
1964	7.61	1.16	8.77	2.26
1965	7.80	1.21	9.01	2.47
1966	8.30	1.28	9.58	2.57
1967	8.81	1.41	10.22	2.54
1968	9.10	1.51	10.60	2.84
1969	9.24	1.59	10.83	3.17
1970	9.64	1.66	11.30	3.42
1971	9.46	1.69	11.16	3.93
1972	9.44	1.74	11.18	4.74
1973	9.21	1.74	10.95	6.26
1974	8.77	1.69	10.46	6.11
1975	8.37	1.63	10.01	6.06
1976	8.13	1.60	9.74	7.31
1977	8.24	1.62	9.86	8.81
1978	8.71	1.57	10.27	8.36
1979	8.55	1.58	10.14	8.46
1980	8.60	1.57	10.17	6.91
1981	8.57	1.61	10.18	6.00
1982	8.65	1.55	10.20	5.11
1983	8.69	1.56	10.25	5.05
1984	8.88	1.63	10.51	5.44
1985	8.97	1.61	10.58	5.07
1986	8.68	1.55	10.23	6.22
1987	8.35	1.60	9.94	6.68
1988	8.14	1.62	9.76	7.40
1989	7.61	1.55	9.16	8.06
1990	7.36	1.56	8.91	8.02
1991	7.42	1.66	9.08	7.63
1992	7.17	1.70	8.87	7.89
1993	6.85	1.74	8.58	8.62
1994	6.66	1.73	8.39	9.00
1995	6.56	1.76	8.32	8.83
1996	6.47	1.83	8.30	9.40

Sources: U.S. Department of Commerce, Bureau of the Census, *Historical Statistics of the United States: Colonial Times to 1970*, Series M 143, 138 (GPO: Washington, DC, 1975).

U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1996*, Table 5.1, p. 137, DOE/EIA-0384(96) (GPO: Washington, DC, 1997).

Notes: Crude oil includes lease condensate. NGPL = Natural gas plant liquids. Imports for years 1941-1949 include crude petroleum products only. Previous year data may have been revised. Current year data are preliminary and may be revised in future publications.

Table 9.5 U.S. Natural Gas Production, 1960-1996

Year	Well with drawals	Repres- suring	Nonhydro- carbon gas removal	Vented and flared	Marketed production	Extraction loss	Total pro- duction
				trillion cubic feet			
1960	15.09	1.75	na	0.56	12.77	0.54	12.23
1961	15.46	1.68	na	0.52	13.25	0.59	12.66
1962	16.04	1.74	na	0.43	13.88	0.62	13.25
1963	16.97	1.84	na	0.38	14.75	0.67	14.08
1964	17.54	1.65	na	0.34	15.55	0.72	14.82
1965	17.96	1.60	na	0.32	16.04	0.75	15.29
1966	19.03	1.45	na	0.38	17.21	0.74	16.47
1967	20.25	1.59	na	0.49	18.17	0.78	17.39
1968	21.33	1.49	na	0.52	19.32	0.83	18.49
1969	22.68	1.46	na	0.53	20.70	0.87	19.83
1970	23.79	1.38	na	0.49	21.92	0.91	21.01
1971	24.09	1.31	na	0.28	22.49	0.88	21.61
1972	24.02	1.24	na	0.25	22.53	0.91	21.62
1973	24.07	1.17	na	0.25	22.65	0.92	21.73
1974	22.85	1.08	na	0.17	21.60	0.89	20.71
1975	21.10	0.86	na	0.13	20.11	0.87	19.24
1976	20.94	0.86	na	0.13	19.95	0.85	19.10
1977	21.10	0.93	na	0.14	20.03	0.86	19.16
1978	21.31	1.18	na	0.15	19.97	0.85	19.12
1979	21.88	1.25	na	0.17	20.47	0.81	19.66
1980	21.87	1.37	0.20	0.13	20.18	0.78	19.40
1981	21.59	1.31	0.22	0.10	19.96	0.77	19.18
1982	20.27	1.39	0.21	0.09	18.58	0.76	17.82
1983	18.66	1.46	0.22	0.09	16.88	0.79	16.09
1984	20.27	1.63	0.22	0.11	18.30	0.84	17.47
1985	19.61	1.92	0.33	0.09	17.27	0.82	16.45
1986	19.13	1.84	0.34	0.10	16.86	0.80	16.06
1987	20.14	2.21	0.38	0.12	17.43	0.81	16.62
1988	21.00	2.48	0.46	0.14	17.92	0.82	17.10
1989	21.07	2.48	0.36	0.14	18.10	0.78	17.31
1990	21.52	2.49	0.29	0.15	18.59	0.78	17.81
1991	21.75	2.77	0.28	0.17	18.53	0.83	17.70
1992	22.13	2.97	0.28	0.17	18.71	0.87	17.84
1993	22.73	3.10	0.41	0.23	18.98	0.89	18.10
1994	23.58	3.23	0.41	0.23	19.71	0.89	18.82
1995	23.74	3.57	0.39	0.28	19.51	0.91	18.60
1996	24.28	3.71	0.36	0.26	19.95	0.93	19.02

Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1996*, Table 6.2, p. 187, DOE/EIA-0384(96) (GPO: Washington, DC, 1997).

Notes: Extraction loss refers to volume reduction resulting from the removal of natural gas plant liquids. Total production refers to dry natural gas. Beginning in 1965, all volumes are shown on a pressure base of 14.73 p.s.i.a. at 60 degrees F. Totals may not agree with sum of components due to independent rounding. Previous year data may have been revised. Current year data are preliminary and may be revised in future publications.

Table 9.6 U.S. Production of Electricity by Prime Mover, 1960-1996

Year	Fossil-fired steam: Coal	Fossil-fired steam: Natural gas	Fossil-fired steam: Petroleum	Internal combustion & gas turbine	Nuclear power	Hydroelectric	Geothermal & other	Total
	billion kilowatt-hours							
1960	403	na	na	4	1	146	<1	756
1961	422	na	na	5	2	152	<1	794
1962	450	na	na	5	2	169	<1	855
1963	494	na	na	5	3	166	<1	917
1964	526	na	na	6	3	177	<1	984
1965	571	na	na	6	4	194	<1	1,055
1966	613	na	na	5	6	195	1	1,144
1967	630	na	na	5	8	222	1	1,214
1968	685	na	na	9	13	222	1	1,329
1969	706	na	na	14	14	250	1	1,442
1970	704	361	174	22	22	248	1	1,532
1971	713	360	206	28	38	266	1	1,613
1972	771	361	253	36	54	273	2	1,750
1973	848	323	296	36	83	272	2	1,861
1974	828	304	279	38	114	301	3	1,867
1975	853	288	273	28	173	300	3	1,918
1976	944	284	302	29	191	284	4	2,038
1977	985	292	338	34	251	220	4	2,124
1978	976	290	345	36	276	280	3	2,206
1979	1,075	311	290	32	255	280	4	2,247
1980	1,162	326	238	28	251	276	6	2,286
1981	1,203	325	202	25	273	261	6	2,295
1982	1,192	291	144	16	283	309	5	2,241
1983	1,259	261	141	17	294	332	6	2,310
1984	1,342	284	117	17	328	321	9	2,416
1985	1,402	279	97	16	384	281	11	2,470
1986	1,386	236	133	16	414	291	12	2,487
1987	1,464	258	115	18	455	250	12	2,572
1988	1,541	236	144	22	527	223	12	2,704
1989	1,554	245	151	29	529	265	11	2,784
1990	1,560	246	113	22	577	279	11	2,808
1991	1,551	246	108	14	613	275	10	2,825
1992	1,576	246	88	21	619	240	10	2,797
1993	1,639	237	96	25	610	265	10	2,883
1994	1,635	260	86	36	640	244	9	2,911
1995	1,653	268	56	44	673	293	6	2,995
1996	1,738	238	50	44	675	329	7	3,078

Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1996*, Table 8.4, p. 233, DOE/EIA-0384(96) (GPO, Washington, DC, 1997).

Notes: Production refers to electric utility net generation of electricity for distribution. Hydroelectric power includes hydroelectric pumped storage. Other includes wood, waste, photovoltaic, and solar thermal energy. Totals may not agree with sum of components due to independent rounding. Previous-year data may have been revised. Current-year data are preliminary and may be revised in future publications.

Table 9.7 U.S. Nuclear Power Plant Operations, 1958-1996

Year	Operable nuclear generating units *number of units*	Net generation of electricity *billion kilowatt-hours*	Year	Operable nuclear generating units *number of units*	Net generation of electricity *billion kilowatt-hours*
1958	1	0.2	1978	70	276.4
1959	1	0.2	1979	68	255.2
1960	3	0.5	1980	70	251.1
1961	3	1.7	1981	74	272.7
1962	5	2.3	1982	77	282.8
1963	6	3.2	1983	80	293.7
1964	6	3.3	1984	86	327.6
1965	6	3.7	1985	95	383.7
1966	[illegible]	5.5	1986	100	414.0
1967	10	7.7	1987	107	455.3
1968	11	12.5	1988	108	527.0
1969	14	13.9	1989	110	529.4
1970	18	21.8	1990	111	576.9
1971	21	38.1	1991	111	612.6
1972	29	54.1	1992	109	618.8
1973	39	83.5	1993	109	610.3
1974	48	114.0	1994	109	640.4
1975	54	172.5	1995	109	673.4
1976	61	191.1	1996	110	674.8
1977	65	250.9			

Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1996*, Table 9.2, p. 257, DOE/EIA-0384(96) (GPO, Washington, DC, 1997).

Notes: Previous-year data may have been revised. Current-year data are preliminary and may be revised in future publications.

Table 9.8 U.S. Net Energy Imports by Source, 1960-1996

Year	Coal	Natural gas (dry)	Petroleum	Other	Total
			quadrillion Btu		
1960	-1.02	0.15	3.57	0.04	2.74
1965	-1.37	0.44	5.01	- 0.02	4.06
1966	-1.35	0.47	5.21	- 0.01	4.32
1967	-1.35	0.50	4.91	- 0.02	4.04
1968	-1.37	0.58	5.73	- 0.02	4.90
1969	-1.53	0.70	6.42	- 0.02	5.56
1970	-1.93	0.77	6.92	- 0.04	5.72
1971	-1.54	0.88	8.07	<0.005	7.41
1972	-1.53	0.97	9.83	0.05	9.32
1973	-1.42	0.98	12.98	0.14	12.68
1974	-1.57	0.91	12.66	0.19	12.19
1975	-1.74	0.90	12.51	0.08	11.75
1976	-1.57	0.92	15.20	0.09	14.65
1977	-1.40	0.98	18.24	0.20	18.02
1978	-1.00	0.94	17.06	0.33	17.32
1979	-1.70	1.24	16.93	0.27	16.75
1980	-2.39	0.96	13.50	0.18	12.25
1981	-2.92	0.86	11.38	0.33	9.65
1982	-2.77	0.90	9.05	0.28	7.46
1983	-2.01	0.89	9.08	0.36	8.31
1984	-2.12	0.79	9.89	0.40	8.96
1985	-2.39	0.90	8.95	0.41	7.87
1986	-2.19	0.69	11.53	0.36	10.38
1987	-2.05	0.94	12.53	0.49	11.91
1988	-2.45	1.22	14.01	0.37	13.15
1989	-2.57	1.28	15.33	0.14	14.18
1990	-2.70	1.46	15.29	0.03	14.08
1991	-2.77	1.67	14.22	0.25	13.36
1992	-2.59	1.94	14.96	0.33	14.64
1993	-1.78	2.25	16.40	0.32	17.19
1994	-1.69	2.52	17.26	0.49	18.58
1995	-2.14	2.74	16.87	0.42	17.90
1996	-2.19	2.75	18.04	0.40	19.00

Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1996*, Table 1.4, p. 11, DOE/EIA-0384(96) (GPO, Washington, DC, 1997).

Notes: Net imports = imports minus exports. Other includes coal coke and small amounts of electricity transmitted across U.S. borders with Canada and Mexico. Other for 1996 does not include coal coke. Totals may not agree with sum of components due to independent rounding. Previous-year data may have been revised. Current-year data are preliminary and may be revised in future publications.

Table 9.9 U.S. Energy Consumption by Sector, 1960-1996

Year	Residential & commercial	Industrial	Transportation	Total
		quadrillion Btu		
1960	13.04	20.16	10.60	43.80
1961	13.44	20.25	10.77	44.46
1962	14.27	21.04	11.23	46.53
1963	14.71	21.95	11.66	48.32
1964	15.23	23.27	12.00	50.50
1965	16.03	24.22	12.43	52.68
1966	17.06	25.50	13.10	55.66
1967	18.10	25.72	13.75	57.57
1968	19.23	26.90	14.86	61.00
1969	20.59	28.10	15.50	64.19
1970	21.71	28.63	16.09	66.43
1971	22.59	28.57	16.72	67.89
1972	23.69	29.86	17.71	71.26
1973	24.14	31.53	18.60	74.28
1974	23.72	30.70	18.12	72.54
1975	23.90	28.40	18.25	70.55
1976	25.02	30.24	19.10	74.36
1977	25.39	31.08	19.82	76.29
1978	26.09	31.39	20.61	78.09
1979	25.81	32.61	20.47	78.90
1980	26.65	30.61	19.69	75.96
1981	25.24	29.24	19.51	73.99
1982	25.63	26.14	19.07	70.85
1983	25.63	25.75	19.13	70.52
1984	26.48	27.86	19.80	74.14
1985	26.70	27.22	20.07	73.98
1986	26.85	26.63	20.81	74.30
1987	27.62	27.83	21.45	76.89
1988	28.92	28.99	22.30	80.22
1989	29.40	29.35	22.56	81.32
1990	29.48	32.14	22.54	84.09
1991	30.09	31.76	22.12	83.99
1933	30.00	33.01	22.46	85.52
1993	31.13	33.30	23.88	87.34
1994	31.29	34.19	23.57	89.21
1995	32.26	34.60	23.96	90.94
1996	33.88	35.43	24.43	93.81

Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1996*, Table 2.1, p. 41, DOE/EIA-0384(96) (GPO, Washington, DC, 1997).

Notes: Beginning in 1990, data include renewable energy. Totals may not agree with sum of components due to independent rounding. Previous-year data may have been revised. Current-year data are preliminary and may be revised in future publications.

Table 9.10 U.S. Energy Consumption per Capita, 1950-1996

Year	Total energy consumption per capita	End-use (net) energy consumption per capita	Year	Total energy consumption per capita	End-use (net) energy consumption per capita
	million Btu			million Btu	
1950	219	194	1974	340	273
1951	230	205	1975	327	261
1952	226	199	1976	342	272
1953	228	201	1977	347	274
1954	218	191	1978	352	276
1955	235	206	1979	351	275
1956	240	210	1980	335	259
1957	236	206	1981	322	246
1958	232	202	1982	305	231
1959	238	206	1983	301	226
1960	244	212	1984	314	236
1961	243	210	1985	310	232
1962	250	216	1986	308	231
1963	256	220	1987	316	237
1964	264	226	1988	326	246
1965	272	232	1989	328	246
1966	285	241	1990	338	256
1967	292	246	1991	333	252
1968	306	257	1992	335	255
1969	319	266	1993	339	258
1970	327	270	1994	343	261
1971	328	270	1995	346	263
1972	340	278	1996	354	269
1973	351	285			

Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1996*, Table 1.5, p. 13, DOE/EIA-0384(96) (GPO, Washington, DC, 1997).

Notes: End-use (net) energy consumption is total energy consumption less losses incurred in the generation, transmission, and distribution of electricity, less power plant electricity use, and less unaccounted for electrical system energy losses. Per capita data are based upon the resident population of the 50 states and the District of Columbia, estimated for July 1 of each year, except for decennial census years when April 1 data are used. Previous-year data may have been revised. Current-year data are preliminary and may be revised in future publications.

Table 9.11 U.S. Energy Consumption per Dollar of Gross Domestic Product, 1959-1996

Year	Petroleum & natural gas	Other energy	Total	Year	Petroleum & natural gas	Other energy	Total
	thousand Btu per chained (1992) $				*thousand Btu per chained (1992) $*		
1959	14.03	5.02	19.05	1978	12.90	4.48	17.38
1960	14.28	5.08	19.37	1979	12.50	4.56	17.06
1961	14.35	4.90	19.25	1980	11.84	4.63	16.47
1962	14.20	4.80	19.00	1981	10.98	4.68	15.66
1963	14.14	4.78	18.92	1982	10.54	4.78	15.32
1964	13.91	4.78	18.68	1983	9.86	4.81	14.66
1965	13.57	4.76	18.33	1984	9.65	4.78	14.43
1966	13.53	4.66	18.19	1985	9.15	4.73	13.88
1967	13.77	4.57	18.33	1986	8.91	4.63	13.53
1968	14.05	4.50	18.55	1987	8.96	4.65	13.61
1969	14.47	4.48	18.95	1988	9.00	4.68	13.68
1970	15.15	4.46	19.61	1989	8.84	4.57	13.42
1971	15.15	4.24	19.40	1990	8.61	5.09	13.70
1972	15.08	4.23	19.31	1991	8.63	5.19	13.82
1973	14.70	4.34	19.04	1992	8.59	5.10	13.70
1974	14.19	4.46	18.66	1993	8.56	5.12	13.68
1975	13.63	4.62	18.25	1994	8.48	5.02	13.50
1976	13.60	4.62	18.22	1995	8.43	5.06	13.49
1977	13.33	4.50	17.83	1996	8.44	5.14	13.58

Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1996*, Table 1.6, p. 15, DOE/EIA-0035(96) (GPO, Washington, DC, 1997).

Notes: See Table 2.1 for chained (1992) dollars of gross domestic product. Current-year data are preliminary and may be revised in future publications.

Table 9.12 U.S. Consumption of Renewable Energy Resources, 1990-1996

Year	Conventional hydroelectric power	Geo-thermal power	Biofuels	Solar energy	Wind energy	Total
			quadrillion Btu			
1990	3.104	0.345	2.632	0.067	0.023	6.171
1991	3.182	0.354	2.642	0.068	0.027	6.273
1992	2.852	0.367	2.788	0.068	0.030	6.106
1993	3.138	0.381	2.784	0.069	0.031	6.403
1994	2.958	0.381	2.838	0.069	0.036	6.282
1995	3.471	0.325	2.946	0.072	0.033	6.847
1996	3.911	0.354	3.017	0.075	0.036	7.393

Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1996*, Table 10.1, p. 263, DOE/EIA-0384(96) (GPO, Washington, DC, 1997).

Notes: Hydroelectricity generated by pumped storage is not included in renewable energy estimates. Conventional hydroelectric power includes electricity net imports from Canada that are derived from hydroelectric energy. Geothermal power includes electricity imports from Mexico that are derived from geothermal energy. Geothermal includes only grid-connected electricity; excludes shaft power and remote electrical power. Biofuels are wood, wood waste, peat, wood sludge, municipal solid waste, agricultural waste, straw, tires, landfill gases, fish oil, and/or other waste, and ethanol blended into motor gasoline. Solar energy includes photovoltaic energy. Wind energy includes only grid-connected electricity; excludes direct heat applications.

Table 9.13 Estimates of U.S. Energy Intensity by Sector, Selected Years, 1977-1995

Year	Residential *million Btu per household*	Commercial *thousand Btu per sq. ft*	Manufacturing *thous. Btu per 1987 $ value of shipments*	Transportation: Passenger automobiles *thous. Btu per vehicle-mile*	Transportation: Freight trucks *thous. Btu per vehicle-mile*
1977	na	na	6.0	9.11	14.16
1978	138	na	5.8	8.96	14.06
1979	126	115.0	5.7	8.73	13.98
1980	114	na	5.5	8.13	13.46
1981	114	na	5.4	7.89	13.39
1982	103	na	4.9	7.56	13.10
1983	na	98.2	4.7	7.31	13.14
1984	105	na	4.5	7.03	13.07
1985	na	na	4.4	6.88	13.12
1986	na	86.6	4.2	6.85	13.08
1987	101	na	4.2	6.52	13.01
1988	na	na	4.3	6.30	12.79
1989	na	91.6	4.3	6.16	12.49
1990	98	na	4.3	5.95	12.17
1991	na	na	4.4	5.77	11.84
1992	na	80.9	na	5.77	11.94
1993	104	na	na	5.95	11.05
1994	na	na	na	5.63	11.12
1995	na	na	na	5.55	11.04

Sources: Davis, T.C., *Transportation Energy Databook: Edition 17*, Table 2.15, p. 2-18, and Table 2.16, p. 2-19, ORNL-6919 (U.S. Department of Energy, Oak Ridge National Laboratory, Oak Ridge, TN, 1997).

U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1995*, Table 2.4, p. 45, DOE/EIA-0384(95) (GPO, Washington, DC, 1996).

—, *Annual Energy Review 1996*, Table 2.8, p. 53 and Table 2.18, p. 75, DOE/EIA-0384(96) (GPO, Washington, DC, 1997).

Notes: na = not available. Residential energy intensity data are derived from the Residential Energy Consumption Survey which was first conducted in 1978 and then triennially since 1984. Commercial energy intensity data are from the Commercial Buildings Energy Consumption Survey, first conducted in 1979 and then triennially since 1983. Manufacturing energy intensity data are derived from the triennial Manufacturing Energy Consumption Survey (MECS). The next MECS will be conducted for the reporting year 1998, with subsequent MECS's being conducted every 4 years thereafter. Transportation energy intensity data are reported annually.

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356

Transportation

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Table 10.1 U.S. Passenger-Miles of Travel: Five-Year Intervals, 1960-1990, and Annually, 1991-1996

Year	Highway	Transit	Rail	Air	Total
			billion passenger-miles		
1960	1,418.00	4.20	17.10	33.40	1,473.00
1965	1,678.00	4.10	13.30	57.60	1,753.00
1970	2,092.00	4.60	6.20	117.50	2,220.00
1975	2,362.00	4.50	3.90	147.40	2,518.00
1980	2,562.00	39.90	4.50	219.00	2,803.00
1985	2,845.90	39.60	4.80	290.10	3,158.00
1990	3,305.00	41.10	6.00	358.90	3,683.00
1991	3,631.00	40.70	6.30	350.30	4,007.00
1992	3,746.00	40.30	6.10	365.[illegible]	4,137.00
1993	3,825.00	39.40	6.20	372.30	4,223.00
1994	3,918.00	39.60	5.90	398.60	4,343.00
1995	3,868.00	39.80	5.50	414.40	4,308.00
1996	3,962.00	41.30	5.10	445.20	4,412.00

Source: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics 1998*, Table 1-10 (DOT, BTS, Washington, DC, 1998).

Notes: BTS has rounded the categories on this table as follows: to the nearest billion passenger-miles; Passenger-Miles, total; Highway, to the nearest 100 million passenger-miles: Air, Transit, and Rail. Highway includes passenger car and taxi, motorcycle, other 2-axle 4-tire vehicle, single unit 2-axle 6-tire or more truck, combination truck, intercity bus, and school bus. Highway passenger-miles are calculated by multiplying vehicle-miles of travel as cited by the U.S. Department of Transportation, Federal Highway Administration by the number of occupants for each vehicle type (as estimated by the U.S. Department of Transportation, Federal Highway Administration using the Nationwide Personal Transportation Survey). Transit includes motor bus, light rail, heavy rail, trolley bus, commuter rail, demand response, ferry boat, and other. Transit passenger-miles are are cumulative sum of the distance ridden by each passenger. Rail includes intercity/Amtrak, which began operations in 1971. Rail passenger-miles represent the movement of one passenger for one mile. Does not include contract commuter passengers. Air includes air carrier, certified domestic service and general aviation. Air carrier passenger-miles are computed by the summation of the products of the aircraft miles flown on each inter-airport hop multiplied by the number of passengers carried on that hop.

Table 10.2 U.S. Ton-Miles of Freight, Five-Year Intervals, 1960-1990, and Annually, 1991-1996

Year	Intercity truck	Class I rail	Domestic air carrier	Domestic water	Oil pipeline
			billion ton-miles		
1960	285.00	572.31	0.55	413.33	229.00
1965	359.00	697.88	1.35	489.80	306.40
1970	412.00	764.81	2.19	596.20	431.00
1975	454.00	754.25	3.47	565.98	507.00
1980	555.00	918.96	4.53	921.84	588.20
1985	610.00	876.98	5.16	892.97	564.30
1990	735.00	1,033.97	9.06	833.54	584.10
1991	758.00	1,038.88	8.86	848.40	578.50
1992	815.00	1,066.78	9.82	856.60	588.80
1993	861.00	1,109.31	10.68	789.68	592.90
1994	908.00	1,200.70	11.80	814.92	591.40
1995	921.00	1,305.69	12.52	807.73	601.10
1996	986.00	1,355.98	12.86	764.69	619.20

Source: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics 1998*, Table 1-11 (DOT, BTS, Washington, DC, 1998).

Notes: Air includes revenue ton-miles of freight, U.S. and foreign mail, and express. Rail includes revenue ton-miles. Domestic water excludes intraterritorial traffic, for which ton-miles were not compiled. Domestic water data for 1980 reflect start up between 1975 and 1980 of Alaska pipeline and subsequent water transport of crude petroleum from Alaskan ports to mainland U.S. for refining.

Table 10.3 Average Annual U.S. Vehicle-Miles of Travel and Fuel Consumption per Vehicle, 1960-1996

Year	Passenger cars[1]		Buses[2]		Other 2 axle, 4 tire vehicles[3]		Single-unit trucks[4]		Trailer combination trucks	
	1,000 vmt	*vmt gallon*	*1,000 vmt*	*vmt gallon*	*1,000 vvmt*	*vmt gallon*	*1,000 vmt*	*vmt gallon*	*1,000 vmt*	*vmt gallon*
1960	9.52	14.3	15.97	5.3	na	na	na	na	na	na
1961	9.52	14.4	15.71	5.3	na	na	na	na	na	na
1962	9.49	14.3	15.67	5.3	na	na	na	na	na	na
1963	9.59	14.6	15.06	5.4	na	na	8.60	8.8	42.63	4.9
1964	9.67	14.6	15.12	5.3	na	na	8.68	8.7	41.48	4.9
1965	9.60	14.5	14.90	5.3	na	na	9.20	9.3	40.26	4.8
1966	9.73	14.1	14.06	5.4	8.08	9.7	6.55	6.2	39.00	5.2
1967	9.85	14.1	13.69	5.4	7.88	9.8	6.63	6.3	40.25	5.2
1968	9.92	13.9	14.00	5.4	8.38	9.9	6.56	6.5	39.64	5.0
1969	9.92	13.6	13.23	5.4	8.36	9.8	7.34	6.7	38.70	4.8
1970	9.99	13.5	12.04	5.5	8.68	10.0	7.36	6.8	38.82	4.8
1971	10.10	13.6	12.09	5.7	9.08	10.2	7.69	6.9	40.49	4.9
1972	10.17	13.5	13.14	5.8	9.53	10.3	8.02	6.5	42.34	5.0
1973	9.88	13.4	13.63	5.9	9.78	10.5	8.15	6.4	44.37	5.1
1974	9.22	13.6	12.72	5.9	9.45	11.0	7.94	6.4	42.37	5.1
1975	9.31	14.0	13.10	5.8	9.83	10.5	8.18	6.4	41.32	5.1
1976	9.42	13.8	13.08	6.0	10.13	10.8	8.37	6.4	40.56	5.1
1977	9.52	14.1	11.87	6.0	10.61	11.2	8.84	6.3	44.92	5.1
1978	9.50	14.3	11.65	5.9	10.97	11.6	9.46	[illegible]	46.95	5.2
1979	9.06	14.6	11.29	6.0	10.80	11.9	9.33	6.0	48.32	5.2
1980	8.81	16.0	11.46	6.0	10.44	12.2	9.10	5.8	48.47	5.3
1981	8.87	16.5	11.48	5.9	10.24	12.5	8.88	5.8	54.82	5.1
1982	9.05	16.9	10.41	5.9	10.28	13.5	9.40	6.0	55.93	5.2
1983	9.12	17.1	8.92	5.9	10.50	13.7	10.12	6.1	56.43	5.3
1984	9.25	17.4	7.95	5.7	11.15	14.0	10.94	6.1	57.74	5.5
1985	9.42	17.5	7.55	5.4	10.51	14.3	9.89	6.1	55.63	5.6
1986	9.46	17.4	7.94	5.3	10.76	14.6	10.58	6.2	57.56	5.6
1987	9.72	18.0	8.85	5.8	11.11	14.9	11.47	6.4	55.89	5.7
1988	9.97	18.8	8.89	5.8	11.47	15.4	11.06	6.4	53.11	5.8
1989	10.16	19.0	9.07	6.0	11.68	16.1	11.26	6.5	53.82	5.8
1990	10.28	20.3	9.13	6.4	11.90	16.1	11.57	6.2	55.21	5.8
1991	10.32	21.2	9.11	6.7	12.25	17.0	11.81	6.5	57.14	5.7
1992	10.57	21.0	8.96	6.6	12.38	17.3	12.33	6.5	59.40	5.8
1993	10.55	20.6	9.36	6.6	12.43	17.4	12.88	6.7	61.37	5.8
1994	10.76	20.8	9.56	6.6	12.16	17.3	12.49	6.8	64.78	5.8
1995	11.20	21.1	9.37	6.6	12.02	17.3	12.48	6.8	68.08	5.8
1996	11.31	21.3	9.38	6.6	11.83	17.3	12.15	6.8	68.20	5.9

Sources: U.S. Department of Transportation, Federal Highway Administration, Office of Highway Information Management, *Highway Statistics Summary to 1995*, Table VM-1 (GPO, Washington, DC, 1997).

—, *Highway Statistics 1996*, Table VM-1 (GPO, Washington, DC, 1997).

Notes: [1]Includes motorcycles. [2]Includes commercial, school, and non-revenue buses. [3]Includes vans, pickup trucks, and sport utility vehicles which are considered passenger vehicles. Prior to 1966, these vehicles were included in the single-unit truck category. [4]Includes 2-axle, 6-tire or more trucks on a single frame.

Table 10.4 U.S. Personal Travel per Household, Driver, and Mode, 1969, 1977, 1983, 1990, and 1995

Characteristics of personal travel	Unit	1969	1977	1983	1990	1995
Persons per household	*no*	3.16	2.83	2.69	2.56	2.44
Licensed drivers per household	*no*	1.65	1.69	1.72	1.75	1.79
Vehicles per household	*no.*	1.16	1.59	1.68	1.77	1.78
Daily vehicle trips per household	*no*	3.83	3.95	4.07	4.66	6.35
Daily vehicle miles per household	*mi*	34.01	32.97	32.16	41.37	57.25
Average vehicle occupancy rate	*per./veh*	na	1.90	1.70	1.60	1.59
Home to work	*per./veh.*	na	1.30	1.30	1.10	1.14
Family & personal business	*per./veh*	na	2.00	1.80	1.80	1.82
Shopping	*per./veh.*	na	2.10	1.80	1.70	1.79
Social & recreation	*per./veh.*	na	2.40	2.10	2.10	2.17
Average vehicle trip length	*mi*	8.90	8.40	7.90	9.00	9.10
Home to work	*mi.*	9.40	9.10	8.50	10.60	11.60
Family & personal business	*mi*	6.50	6.80	6.70	7.40	na
Shopping	*mi.*	4.40	5.00	5.30	5.10	na
Social & recreation	*mi*	13.10	10.30	10.50	11.80	na
Vacation	*mi.*	160.00	77.90	113.90	114.90	na
Average distance to work	*mi*	9.40	9.20	8.50	10.60	11.60
by automobile	*mi.*	9.40	9.10	9.90	10.40	na
by truck	*mi.*	14.20	10.60	11.40	13.00	na
by bus	*mi.*	8.70	7.20	8.60	9.30	na
Average annual travel per driver	*1,000 mi.*	8.69	9.92	10.29	13.13	na
by male drivers	*1,000 mi*	11.35	13.40	13.96	16.64	na
by female drivers	*1,000 mi.*	5.41	5.94	6.38	9.53	na
Average annual personal travel*	*1,000 mi.*	7.66	9.47	9.14	10.42	na
by private vehicle	*1,000 mi.*	na	8.15	7.52	9.18	na
by public vehicle	*1,000 mi.*	na	0.25	0.24	0.24	na
by other mode	*1,000 mi.*	na	1.06	1.37	0.97	na

Sources: U.S. Department of Transportation, Federal Highway Administration, *1990 NPTS Databook: Nationwide Personal Transportation Study*, Vol. I (DOT, FHWA, Washington, DC, 1993).

--, *1990 NPTS Databook: Nationwide Personal Transportation Study*, Vol. II (DOT, FHWA, Washington, DC, 1995).

--, *Our Nation's Travel: 1995 NPTS Early Results Report, Technical Appendix* (DOT, FHWA, Washington, DC, 1997).

Notes: *per person. Household vehicles include automobiles, station wagons, and vanbuses/mini-buses, and, except for 1969, light pickups and other light trucks. Household vehicles are those that are owned, leased, rented, or company owned and left at home to be regularly used by household members. They also include vehicles used solely for business purposes or business-owned vehicles if left at home and used for the home-to-work trip (e.g., taxicabs and police cars). Average vehicle trip length for 1969 is for automobiles only. Family and personal business includes vehicle trips to shop, pickup or deposit passengers, shoe repair, haircuts, etc. Social recreation includes vehicle trips to visit relatives and friends, go to a movie or play, attend or participate in a sporting event, etc. Private vehicle modes of travel include automobile, van, pick-up truck, and motorcycle. Public transportation includes bus, commuter rail, subway, elevated rail, streetcar, and trolley. Other includes airplane, Amtrak, taxi, school bus, moped, bicycle, and, except for 1969, walking.

Table 10.5 Journey-To-Work Mode for U.S. Working Population, 1960-1990

Mode of transportation	1960	1970	1980	1990
	U.S. working population, in millions			
Private vehicle	42.99	61.96	83.02	101.29
Public transit	7.81	6.51	6.01	5.89
Walked to work	6.42	5.69	5.41	4.49
Worked at home	4.66	2.69	2.18	3.41
Total	61.87	76.85	96.62	115.07
	percent of U.S. working population			
Private vehicle	69.48	80.63	85.92	88.02
Public transit	12.62	8.48	6.22	5.12
Walked to work	10.37	7.40	5.60	3.90
Worked at home	7.54	3.49	2.26	2.96

Source: U.S. Department of Commerce, Bureau of the Census, *Census of Population and Housing* for 1960, 1970, 1980, and 1990 (GPO, Washington, DC, decennial).

Table 10.6 Congestion on U.S. Urban Interstate Highways, Selected Years, 1975-1996

Year	Peak-hour travel time under congested conditions	Peak-hour miles traveled under congested conditions	Average daily vehicles per lane
	percent		*thousands*
1975	41	23	na
1978	48	29	na
1980	52	28	na
1982	53	28	na
1984	55	30	9.99
1986	63	37	10.79
1988	67	42	11.68
1990	69	45	12.26
1992	70	46	12.38
1994	68	45	12.81
1996	54	33	13.38

Source: U.S. Department of Transportation (DOT), Federal Highway Administration (FHWA), *Highway Statistics 1996*, Chart "Urban Interstate System Congestion Trends," p. V-70 (DOT, FHWA, Washington, DC, 1997).

Notes: Congestion refers to percent of mileage or peak hour travel with the volume-to-service ratio equal to or greater than 0.80. Congestion data for 1996 not strictly comparable to data for previous years because of changes in capacity (service flow) calculation procedures.

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364

Global Atmosphere and Climate

365

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Table 11.1 World Population, Energy Consumption, and Energy-Related Carbon Dioxide Emissions by Region, 1986-1995

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
North America										
Population	346	350	354	358	363	369	374	379	383	388
Energy consumption	89	92	96	98	98	98	99	101	103	106
CO_2 emissions	1,385	1,436	1,515	1,541	1,474	1,494	1,527	1,527	1,663	1,694
Cen & So America										
Population	327	333	339	346	352	358	364	370	376	383
Energy consumption	13	13	14	14	14	15	15	16	17	17
CO_2 emissions	163	175	178	179	177	186	194	204	224	234
Western Europe										
Population	446	448	451	454	457	460	463	466	468	471
Energy consumption	61	62	63	64	64	65	64	64	64	66
CO_2 emissions	909	912	883	912	920	900	885	872	859	890
Eastern Europe										
Population	379	382	383	385	390	392	392	392	392	393
Energy consumption	70	72	74	73	71	67	63	59	53	51
CO_2 emissions	1,298	1,347	1,368	1,335	1,223	1,173	1,060	1,009	880	934
Middle East										
Population	116	119	123	126	130	134	137	141	145	149
Energy consumption	9	10	10	11	11	11	12	13	13	14
CO_2 emissions	147	146	157	163	167	312	200	208	235	243
Africa										
Population	574	591	608	624	641	661	682	703	724	746
Energy consumption	10	10	10	10	10	11	11	11	12	12
CO_2 emissions	169	168	178	180	182	186	194	195	198	196
Far East & Oceania										
Population	2,740	2,785	2,836	2,887	2,934	2,982	3,030	3,078	3,145	3,195
Energy consumption	61	64	69	72	74	77	80	86	91	96
CO_2 emissions	1,199	1,256	1,356	1,383	1,449	1,534	1,611	1,659	1,785	1,875
WORLD										
Population	4,927	5,009	5,094	5,180	5,266	5,356	5,442	5,528	5,634	5,724
Energy consumption	313	323	335	341	343	343	345	351	354	362
CO_2 emissions	5,270	5,440	5,635	5,693	5,593	5,785	5,671	5,674	5,844	6,066

Sources: U.S. Department oif Energy, Energy Information Administration, *International Energy Annual 1995*, Appendix Table E1, pp. 169-170, and Appendix Table B1, pp.121-124, DOE/EIA-0219(95) (GPO, Washington, DC, 1996).

Marland, G. and T. Boden, Oak Ridge National Laboratory, "Global CO_2 Emissions From Fossil-Fuel Burning, Cement Production, and Gas Flaring," NDP-030/R7 (an Internet accessible numerical database) (Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, TN, 1997).

Notes: Population is expresser' in millions, energy consumption in quadrillion Btus, and CO_2 emissions in million metric tons of carbon and rounded to the nearest integer. Energy-related carbon dioxide emissions refers to emissions from fossil fuel burning and gas flaring; excludes emissions from cement production. Regional grouping of countries in sources have been reconciled as follows. North America includes Mexico, Western Europe includes Germany and Turkey; Eastern Europe includes the former USSR, and Far East and Oceania includes Centrally Planned Asia.

Table 11.2 Global Emissions of Carbon Dioxide From Fossil-Fuel Burning, Cement Production, and Gas Flaring, Five-Year Intervals, 1950-1960, and Annually, 1961-1995

Year	Fossil-fuel burning: Solid	Fossil-fuel burning: Liquid	Fossil-fuel burning: Gas	Cement production	Gas flaring	Total	Per capita
	million metric tons of carbon						*tons*
1950	1,070	423	97	18	20	1,627	0.6
1955	1,208	625	150	30	26	2,039	0.7
1960	1,411	850	235	43	24	2,563	0.8
1961	1,349	905	254	45	24	2,577	0.8
1962	1,351	981	277	49	23	2,681	0.9
1963	1,397	1,053	300	51	25	2,826	0.9
1964	1,435	1,138	328	57	31	2,989	0.9
1965	1,461	1,221	351	59	36	3,127	0.9
1966	1,478	1,325	380	63	39	3,285	1.0
1967	1,448	1,424	410	65	52	3,399	1.0
1968	1,448	1,552	445	70	56	3,571	1.0
1969	1,487	1,674	487	74	67	3,789	1.0
1970	1,556	1,838	516	78	76	4,064	1.1
1971	1,556	1,946	554	84	88	4,227	1.1
1972	1,572	2,055	583	89	94	4,395	1.1
1973	1,580	2,240	608	95	110	4,633	1.2
1974	1,577	2,244	618	96	107	4,641	1.2
1975	1,671	2,131	623	95	93	4,613	1.1
1976	1,708	2,313	647	103	109	4,880	1.2
1977	1,770	2,389	646	108	104	5,018	1.2
1978	1,786	2,383	674	116	107	5,068	1.2
1979	1,882	2,534	714	119	100	5,348	1.2
1980	1,938	2,407	726	120	89	5,279	1.2
1981	1,910	2,271	736	121	72	5,109	1.1
1982	1,973	2,176	731	121	69	5,069	1.1
1983	1,978	2,161	733	125	63	5,060	1.1
1984	2,070	2,185	791	128	58	5,231	1.1
1985	2,225	2,170	822	131	57	5,404	1.1
1986	2,286	2,279	840	137	54	5,596	1.1
1987	2,337	2,289	903	143	51	5,723	1.1
1988	2,401	2,392	949	152	53	5,947	1.2
1989	2,434	2,429	983	156	50	6,053	1.2
1990	2,374	2,498	1,020	157	60	6,109	1.2
1991	2,311	2,606	1,030	161	70	6,178	1.1
1992	2,337	2,497	1,019	169	62	6,084	1.1
1993	2,275	2,498	1,040	177	63	6,053	1.1
1994	2,435	2,541	1,064	188	64	6,292	1.1
1995	2,540	2,568	1,140	193	64	6,506	1.1

Source: Marland, G. and T. Boden, Oak Ridge National Laboratory, "Global CO_2 Emissions From Fossil-Fuel Burning, Cement Production, and Gas Flaring," NDP-030/R7 (an Internet accessible numerical database) (Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, TN, 1997)

Table 11.3 Global Production and Atmospheric Release of Chlorofluorocarbons, 1960-1995

	CFC-11 Annual		CFC-11 Cumulative			CFC-12 Annual		CFC-12 Cumulative		
Year	Prod	Rel	Prod	Rel	Unrel	Prod	Rel	Prod	Rel	Unrel
	million kilograms									
1960	50	41	287	252	39	99	89	828	695	155
1961	61	52	347	305	48	109	100	937	794	166
1962	78	65	425	370	62	128	115	1,065	909	183
1963	93	80	519	450	77	146	134	1,211	1,043	199
1964	111	95	630	545	94	170	156	1,381	1,198	218
1965	123	108	753	653	111	190	175	1,571	1,374	237
1966	141	121	894	775	133	216	195	1,788	1,569	264
1967	160	138	1,053	912	157	243	220	2,030	1,788	293
1968	183	157	1,237	1,069	186	268	247	2,298	2,035	320
1969	217	182	1,454	1,251	225	297	274	2,595	2,309	351
1970	238	207	1,692	1,457	260	321	300	2,916	2,609	380
1971	263	227	1,955	1,684	300	342	322	3,258	2,931	408
1972	307	256	2,262	1,940	356	380	350	3,638	3,281	448
1973	349	292	2,611	2,233	418	423	387	4,061	3,668	495
1974	370	321	2,981	2,554	472	443	419	4,504	4,087	530
1975	314	311	3,295	2,865	479	381	404	4,885	4,491	516
1976	340	317	3,635	3,182	508	411	390	5,296	4,881	547
1977	321	304	3,955	3,486	529	383	371	5,678	5,252	568
1978	309	284	4,264	3,769	559	372	341	6,050	5,594	608
1979	290	264	4,554	4,033	589	357	338	6,408	5,931	637
1980	290	251	4,843	4,284	632	350	333	6,758	6,264	663
1981	287	248	5,130	4,532	675	351	341	7,109	6,604	683
1982	271	[illegible]	5,402	4,771	711	328	337	7,437	6,942	681
1983	292	[illegible]	5,693	5,024	755	355	343	7,793	7,285	702
1984	312	271	6,006	5,295	801	382	359	8,175	7,645	735
1985	327	281	6,332	5,576	851	376	368	8,551	8,013	752
1986	350	295	6,683	5,871	912	398	377	8,949	8,389	784
1987	382	311	7,065	6,182	989	425	387	9,374	8,776	833
1988	376	315	7,441	6,496	1,056	421	393	9,795	9,169	871
1989	303	265	7,743	6,761	1,098	380	365	10,175	9,533	896
1990	233	216	7,976	6,978	1,118	[illegible]	311	10,406	9,844	822
1991	214	188	8,190	7,166	1,147	225	272	10,631	10,116	781
1992	186	171	8,376	7,337	1,165	216	255	10,847	10,371	747
1993	147	158	8,523	7,495	1,156	215	328	11,062	10,609	729
1994	60	137	8,583	7,632	1,080	134	212	11,195	10,820	655
1995	33	124	8,616	7,756	989	83	189	11,278	11,009	551

Source: Alternative Fluorocarbons Environmental Acceptability Study, *Production, Sales and Atmospheric Release of Fluorocarbons Through 1995* (AFEAS, Washington, DC, 1997).

Notes: Prod = Produced. Rel = Released. Unrel = Unreleased. Data are rounded to the nearest million kilograms. Production data are voluntarily reported by the chemical industry through a survey conducted by an independent accountant, Grant Thornton LLP. The companies surveyed have production in the following countries: Argentina, Australia, Brazil, Canada, the European Union, Japan, Mexico, South Africa, United States, and Venezuela. Data collected by AFEAS for 1995 represent a diminished fraction of global CFC production, informally estimated to be less than 50%. Global coverage for previous years is estimated to be as follows: 1982, 87%; 1983, 86%; 1984, 85%; 1985, 83%; 1986, 82%; 1987, 80%; 1988, 79%; 1989, 78%; 1990, 70%; 1991, 70%; 1992, 75%; 1993, <75%; and 1994, <60%. For years prior to 1982, global coverage is assumed to be 100%. Atmospheric release of CFCs is calculated using data compiled by Grant Thornton LLP and assumptions about the rate of release from end-use applications.

Table 11.4 Global Atmospheric Concentrations of Greenhouse and Ozone-depleting Gases, 1970-1996

Year	Carbon dioxide (CO_2) *ppm*	Carbon tetra-chloride (CCl_4) *ppt*	Methyl chloro form *ppt*	CFC-11 (CCl_3F) *ppt*	CFC-12 *ppt*	CFC-113 *ppt*	Total chlorine (gas) *ppt*	Nitrous oxide (N_2O) *ppb*	Meth-ane (CH_4) *ppb*
1970	325.5	na	na	na	na	na	na	na	na
1971	326.2	na	na	na	na	na	na	na	na
1972	327.3	na	na	na	na	na	na	na	na
1973	329.5	na	na	na	na	na	na	na	na
1974	330.1	na	na	na	na	na	na	na	na
1975	331.0	na	na	na	na	na	na	na	na
1976	332.0	na	na	na	na	na	na	na	na
1977	333.7	na	na	na	na	na	na	na	na
1978	335.3	88	58	139	257	na	1,457	298	na
1979	336.7	88	63	147	272	na	1,529	299	na
1980	338.5	90	71	158	289	na	1,622	299	na
1981	339.8	91	76	166	305	na	1,698	299	na
1982	341.0	93	82	175	325	26	1,871	301	na
1983	342.6	94	86	182	341	28	1,945	302	na
1984	344.3	95	89	190	355	31	2,024	303	na
1985	345.7	97	93	200	376	36	2,127	304	na
1986	347.0	98	97	209	394	40	2,222	305	1,600
1987	348.8	100	100	219	411	48	2,321	306	1,611
1988	351.3	101	104	231	433	53	2,432	306	1,619
1989	352.7	101	108	240	452	59	2,531	306	1,641
1990	354.0	102	111	249	469	66	2,626	307	1,645
1991	355.5	102	114	254	483	71	2,691	307	1,657
1992	356.3	101	118	260	496	77	2,762	308	1,673
1993	357.0	101	113	260	502	79	2,768	308	1,671
1994	358.8	92	106	262	512	81	2,774	309	1,673
1995	361.0	99	97	261	519	82	na	309	1,681
1996	362.6	99	87	261	522	82	na	310	1,669

Sources: Carbon dioxide: Keeling, C.D., Scripps Institution of Oceanography, "Atmospheric CO_2 Concentrations – Mauna Loa Observatory, Hawaii, 1958-1996," NDP-001-R7 (an Internet accessible numerical database) (Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, TN, 1997).

Trace gases: Prinn, R.G., et al., "Continuous High Frequency Gas Chromatographic Measurements of CH_4, N_2O, CFC-11, CFC-12, CFC-113, methyl chloroform, and carbon tetrachloride," NDP-ale (1978-1985), NDP-gage (1981-1996), and NDP-agage (1994-1996) (Internet accessible numerical databases) (Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, TN, 1997).

Notes: ppm = parts per million. ppb = parts per billion. ppt = parts per trillion. CFC = Chlorofluorocarbon. All estimates are by volume. 1996 trace gas concentrations are for the first quarter only.

Table 11.5 Annual Global Surface Temperature Anomalies, 1960-1996

	Global	North Hemisphere	South Hemisphere	Tropical	South Polar	South Temperate	South Subtropical	Equator	North Subtropical	North Temperate	North Polar
					degrees Celsius						
1960	0.00	-0.11	0.11	0.05	-0.85	0.52	0.23	0.02	-0.09	-0.15	-0.19
1961	0.24	0.24	0.28	0.00	0.24	0.57	0.10	0.11	-0.22	0.55	0.67
1962	0.12	0.13	0.13	-0.05	-0.66	0.68	0.09	-0.11	-0.11	0.23	0.60
1963	0.09	0.16	0.01	0.04	-0.23	0.27	-0.10	-0.04	0.26	0.29	-0.09
1964	-0.24	-0.31	-0.18	-0.23	-0.52	-0.09	-0.08	-0.21	-0.40	-0.27	-0.30
1965	-0.17	-0.24	-0.10	-0.20	-0.43	0.20	-0.18	-0.22	-0.20	-0.40	0.02
1966	-0.05	-0.22	0.11	-0.06	0.60	0.20	-0.19	0.05	-0.03	0.09	-1.45
1967	0.04	0.06	0.01	-0.13	0.39	-0.11	0.03	-0.15	-0.26	0.38	0.30
1968	-0.10	-0.07	-0.13	-0.18	-0.28	0.11	-0.34	-0.04	-0.16	0.05	-0.15
1969	-0.14	-0.14	-0.14	0.23	0.12	-0.68	0.10	0.21	0.37	-0.83	-0.15
1970	-0.05	0.09	-0.19	0.05	0.06	-0.47	-0.11	0.01	0.26	-0.08	0.17
1971	-0.22	-0.16	-0.28	-0.21	0.10	-0.55	-0.20	-0.29	-0.15	-0.16	-0.05
1972	-0.19	-0.20	-0.19	-0.01	0.20	-0.62	-0.05	0.02	0.02	-0.45	-0.34
1973	0.19	0.25	0.13	0.40	0.53	-0.48	0.40	0.37	0.43	-0.13	0.50
1974	-0.03	-0.06	0.01	-0.03	1.01	-0.37	-0.13	0.03	0.01	-0.26	0.15
1975	0.07	0.16	-0.02	0.00	1.09	-0.52	-0.07	-0.01	0.08	0.40	0.01
1976	-0.24	-0.15	-0.33	-0.11	-0.27	-0.49	-0.34	-0.09	0.10	-0.41	-0.20
1977	0.16	0.12	0.20	0.31	0.70	-0.14	0.23	0.28	0.41	-0.09	-0.24
1978	0.10	0.16	0.06	0.24	-0.14	0.03	0.01	0.37	0.34	-0.14	0.15
1979	0.18	0.12	0.23	0.29	0.43	0.16	0.01	0.57	0.29	-0.01	-0.45
1980	0.38	0.31	0.46	0.53	0.97	0.12	0.61	0.32	0.67	0.02	0.15
1981	0.42	0.58	0.26	0.30	0.96	0.07	0.13	0.20	0.57	0.71	0.75
1982	0.20	0.16	0.25	0.43	-0.07	0.07	0.54	0.37	0.37	0.06	-0.29
1983	0.43	0.53	0.34	0.43	0.97	-0.36	0.65	0.46	0.18	1.11	0.12
1984	0.29	0.25	0.34	0.33	0.93	-0.21	0.69	0.11	0.19	0.28	0.44
1985	0.02	-0.21	0.25	0.18	0.53	0.16	0.21	0.24	0.10	-0.69	-0.31
1986	0.14	0.13	0.16	0.26	0.45	-0.17	0.26	0.31	0.21	-0.05	0.13
1987	0.46	0.30	0.61	0.92	0.42	0.10	0.96	1.12	0.68	-0.01	-0.63
1988	0.37	0.41	0.33	0.45	1.37	-0.46	0.44	0.65	0.26	0.45	0.40
1989	0.24	0.48	-0.01	0.15	-0.29	-0.14	0.11	0.28	0.07	0.73	1.02
1990	0.56	0.76	0.36	0.50	0.57	0.01	0.38	0.79	0.33	1.04	1.04
1991	0.48	0.46	0.51	0.56	1.25	-0.03	0.62	0.59	0.44	0.33	0.64
1992	0.14	0.08	0.20	0.40	0.76	-0.69	0.84	0.15	0.22	0.05	-0.23
1993	0.16	0.30	0.02	0.33	-0.09	-0.42	0.35	0.32	0.32	-0.14	1.10
1994	0.35	0.54	0.15	0.55	-0.42	-0.10	0.42	0.65	0.59	0.54	0.36
1995	0.64	0.98	0.28	0.76	0.17	-0.40	0.85	0.64	0.78	1.13	1.45
1996	0.46	0.49	0.42	0.67	1.54	-0.32	0.62	0.35	1.05	-0.16	0.84

Source: Angell, J.K. Air Resources Laboratory, National Oceanic and Atmospheric Administration, "Annual and Seasonal Global Temperature Anomalies in the Troposphere and Low Stratosphere, 1958-1996," NDP-008/R4 (an Internet accessible numerical database) (Carbon Dioxide Information Analysis Center, Oak Ridge, TN, 1997).

Notes: Zonal regions are defined as follows: Northern Hemisphere (equator - 90 N), Southern Hemisphere (equator - 90 S), Tropical (30 S - 30 N), South Polar (90 S - 60 S), South Temperate (60 S - 30 S), South Subtropical (30 S - 10 S), Equator (10 N - 10 S), North Subtropical (10 N - 30 N), North Temperate (30 N - 60 N), and North Polar (60 N - 90 N).

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Appendices

NEPA Statistical Tables

Environmental Statistics Programs Managed by Agencies of the U.S. Government

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NEPA Statistical Tables

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Table 1. NEPA Cases by Agency for 1995

Agencies	Number of cases filed	Number resulting in injunctions	Number of injunctions from pre-1995 cases
Agriculture, Department of	11	3	0
Air Force, Department of	0	0	0
Army, Department of	0	0	0
Commerce, Department of	7	2	0
Energy, Department of	1	0	2
Environmental Protection Agency	4	0	0
Federal Emergency Management Agency	0	0	0
Federal Energy Regulatory Commission	1	0	0
Health & Human Services, Department of	1	0	0
Housing & Urban Development, Department of	3	0	0
Navy, Department of	2	0	0
Nuclear Regulatory Commission	1	0	1
Surface Transportation Board	0	0	0
Transportation, Department of	11	0	1
Treasury, Department of	1	0	0
Tennessee Valley Authority	0	0	0
U.S. Army Corps of Engineers	21	2	1
TOTAL	**64**	**7**	**5**

Table 2. Causes of Action Filed Under NEPA in 1995 and 1996

Causes of Action	Pre-1995 where injunction issued in 1995-1996	1995	1996
Inadequate Environmental Impact Statement	1	19	31
No Environmental Impact Statement	3	23	40
Inadequate Environmental Assessment	1	20	26
No Environmental Assessment	0	5	8
No Supplemental Environmental Impact Statement	0	0	8
Other	0	2	11
TOTAL	**5**	**69**	**124**

Table 3. Agencies Reporting No NEPA Litigation for 1995 and 1996

Central Intelligence Agency
Committee for Purchase from People who are Blind or Severely Disabled
Department of Education
Department of State
Department of Veterans Affairs
Export-Import Bank of the United States
Farm Credit Administration
Federal Deposit Insurance Corporation
Federal Election Commission
Federal Labor Relations Authority
Federal Maritime Commission
Federal Trade Commission
International Boundary and Water Commission
Merit System Protection Board
Overseas Private Investment Corporation
Peace Corps
United States Consumer Product Safety Commission
United States Small Business Administration
United States Information Agency
United States International Trade Commission
United States Postal Service

Table 4. Plaintiffs for NEPA Lawsuits in 1995 and 1996

Plaintiffs	Pre-1995 where injunction issued in 1995-1996	1995	1996
Environmental Groups	4	25	41
Individuals or Citizen Groups	1	22	30
State Governments	1	4	2
Local Governments	0	6	17
Business Groups	0	7	3
Property Owners or Residents	0	10	11
Indian Tribes	0	3	3
Other	0	0	1
TOTAL	**6**	**77**	**108**

Environmental Statistics Programs Managed by Agencies of the U.S. Government

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Program	Sponsor	Coverage	Frequency/ Most Recent Report
Major Uses of Land in the United States	USDA Economic Research Service	State, regional, and national estimates of acreage in 15 land uses between years 1945-1992.	Five-year intervals coincide with USDA Census of Agriculture; 1995 report[1] and database[2]. Annual reports for crop-land used for crops[3]
National Resources inventory	USDA Natural Resources Conservation Service	Determines status, condition, and trends of soil, water, and related resources on nonfederal lands. Data are used to formulate policy and assist in strategic planning of conservation and environmental programs at national, regional, and local levels.	Surveys are conducted every 5 years, 1995 report with 1992 data[4]. Data key to development of *Geography of Hope*[5] and *State of the Land* reports.[6]
Agricultural Chemical Usage Statistics	USDA National Agricultural Statistics Service and Economic Research Service	Estimated treated acreage and application quantity of fertilizer nutrients and pesticide ingredients applied to field crops, vegetables, and fruits; includes state estimates for those states where the commodities are predominantly produced.	Annual collection for field crops; 1998 report with 1997 data.[7] Biennial reports for vegetables and fruits; 1997 report for vegetables with 1996 data[8] and 1998 report for fruits with 1997 data.[9] Annual collection for restricted use pesticides; 1997 report with 1996 data.[10]

Notes:

1 http://www.econ.ag.gov/epubs/pdf/arei/97upd/upd97-3.pdf
2 http://usda.mannlib.cornell.edu/data-sets/land/89003/
3 http://www.econ.ag.gov/epubs/pdf/arei/97upd/upd97-5.pdf
4 http://www.nhq.nrcs.usda.gov/NRI/intro.html
5 http://www.nhq.nrcs.usda.gov/CCS/GHopeHit.html
6 http://www.nhq.nrcs.usda.gov/land/home.html
7 http://usda.mannlib.cornell.edu/data-sets/inputs/9x171/97171
8 http://usda.mannlib.cornell.edu/data-sets/inputs/9Y172/97172
9 http://mannlib.cornell.edu/data-sets/inputs/9x172/96172
10 http://jan.mannlib.cornell.edu/reports/nassr/other/pcu-bb/agricultural_chemical_usage_1996_restricted_use_pesticides_summary_12.18.97

Program	Sponsor	Coverage	Frequency/ Most Recent Report
Forest Insect and Disease Conditions in the United States	USDA Forest Service	Data for U.S. federal, state, and private forest lands; data analyses by region, ownership, type of insect/ disease, and area affected; trend data available.	Annual collection; 1998 report with 1997 data.
Forest Health Monitoring Program	USDA Forest Service	Measures, interprets, and reports effects of forest pests, air pollution, other stressors, and management methods on the health of U.S. forests in three increasingly intensive phases: detection monitoring to determine annual differences from baseline conditions or trends; in-depth evaluation monitoring to determine cause, extent, and severity of detected changes; and intensive-site ecosystem monitoring to provide detailed, long-term research data for predicting future conditions.	Annual assessment; 1997 update.[11]
Forest Inventory and Analysis	USDA Forest Service	Inventory with trend information on extent, condition, ownership, and composition of U.S. forests; wildlife habitat, forage production, and other resource characteristics.	5-year cycle; 1993 report with 1992 data;[12] 1997 update in progress.
Land Areas of the National Forest System	USDA Forest Service	Data on extent and characteristics of forest, range, and related lands in the National Forest System.	Annual reports.[13]
Tree Planting in the United States	USDA Forest Service	Summary of tree planting in the United States.	Annual reports; 1996 report with 1996 data.

Notes:

[11] http://www.fs.fed.us/foresthealth/fh_index.html
[12] http://www.srsfia.usfs.msstate.edu/rpa/rpa.htm
[13] http://www.fs.fed.us/database/lar/

Program	Sponsor	Coverage	Frequency/ Most Recent Report
Pollution Abatement Control Expenditures (PACE)	DOC Bureau of Economic Analysis	Summary of all spending for PAC by business, government, and consumers, and by type.	Annual reports; 1996 report with 1994 data.[14] This series was discontinued after 1994.
Survey of Pollution Abatement Costs and Expenditures	DOC Bureau of the Census	Annual operating costs and capital expenditures for pollution abatement activities in manufacturing industries.	Annual collection, 1973-1994 (except 1987).[15] This series was discontinued after 1994.
National Shellfish Register of Classified Waters	NOAA National Ocean Service	Reports on status of classified shellfishing waters as indicators of bacterial water quality nationwide; state classification of growing waters for commercial harvest of oysters, clams, andmussels based on actual or potential pollution sources and coliform bacteria levels in surface waters.	5-year cycle; 1995 register and CD-ROM.[16]
Fisheries Statistics Program	NOAA National Marine Fisheries Servicel	National compilation, analysis, and dissemination of biological, economic, and sociological statistics from U.S. commercial (domestic and high seas) and recreational fisheries. Mostly marine; historical time series, some dating back to 1800s; some world (FAO, EC) fishery data, foreign nation data on fisheries in U.S. waters. Data types include landings, prices and fishing efforts; number of vessels, gear and fishermen; annual processed products; trade in fisheries products; species composition; length frequencies; per capita consumption; and aquaculture.	Collect daily/ monthly/yearly information from primary and secondary sources; monthly, quarterly, and annual publications.[17]

Notes:

[14]http://www.bea.gov/bea/an/0996eed/maintext.htm
[15]http://www.census.gov/prod-bin/pubgate.pl?/prod/2/manmin/ma200x94.pdf
[16]http://www-orca.nos.noaa.gov/projects/95register/
[17]http://www.st.nmfs.gov/st1/fus/fus96/index.html

Program	Sponsor	Coverage	Frequency/ Most Recent Report
National Climatic Data	NOAA National Climatic Data Center (NCDC)	NCDC collects, processes, archives, and disseminates worldwide meteorological and climatological data from a global network of stations; coverage is global, land and sea, primarily of U.S. dependencies, especially for summarized data.	Responds to over 33,000 user requests per year; data records date from mid-nineteenth century to present.[18]
National Oceanographic Data	NOAA National Oceanographic Data Center (NODC)	NODC collects, processes archives, and disseminates such worldwide oceanographic data as marine biology, marine pollution, wind and waves, surface and subsurface currents, and temperature.	Responds to over 10,000 user requests per year; data records date from late-nineteenth century to present.[19]
National Geophysical Data	NOAA National Geophysica Data Center (NGDC)	NGDC collects, processes, archives, and disseminates such worldwide geophysical data as solid earth geophysics, earthquake seismology, geomagnetic surveys, marine geology and geophysics, solar-terrestrial physics, and glaciology.	Responds to 11,000 user requests per year; data records date from mid-nineteenth century to present.[20]
National Coastal Pollutant Discharge Inventory	NOAA National Ocean Service (NOS) Ocean Resources Conservation and Assessment (ORCA)	Compiles pollutant-loading estimates for point and non-point sources and riverine input in coastal counties and watersheds. Such sources discharge to the estuarine, coastal, and oceanic waters of the contiguous United States, excluding the Great Lakes.	East, West and Gulf Coast estimates for 1991 will be available in late 1997. 1991 data for Gulf of Maine available.[21]

Notes:

[18]http://www.ncdc.noaa.gov/phase3/productaccm.htm
[19]http://www.nodc.noaa.gov/NODC-products.html
[20]http://www.ngdc.noaa.gov/
[21]http://www-orca.nos.noaa.gov/projects/gomaine

Program	Sponsor	Coverage	Frequency/ Most Recent Report
National Status and Trends Program	NOAA National Ocean Service (NOS) Ocean Resources Conservation and Assessment (ORCA)	A national monitoring program to observe and assess the status and trends in environmental quality conditions in U.S. estuarine and coastal waters, and to identify the relations of these conditions to natural and anthropogenic influences.	Reports from annual sampling at over 200 sites to monitor the spatial[22] and temporal[23] trends in chemical contamination.[24] Bio-effects monitoring surveys,[25] intensive two-to-four year studies, are being conducted to investigate contaminant effects on coastal organisms in areas determined through national monitoring to have persistently high levels of one or more contaminants.
National Estuarine Inventory	NOAA National Ocean Service (NOS) Ocean Resources Conservation and Assessment (ORCA)	Compiles, evaluates, and assesses information on 102 estuaries in the continental United States, including data on salinity, bottom sediments, freshwater inflow, pesticide use, land use, distribution of estuarine fishes and invertebrates,population, water quality, recreation use, and wetlands.	Many projects are ongoing assessments; others involve a snapshot view of existing data. Topics of the Coastal Trends series include coastal population,[26] coastal wetlands (1991), housing starts (1992),[27] agricultural pesticide use (1992);estuaries (1990);[28] and eutrophication (ongoing).

Notes:

[22]http://www-orca.nos.noaa.gov/projects/nsandt/spatial.html
[23]http://www-orca.nos.noaa.gov/projects/nsandt/temporal.html
[24]http://www-orca.nos.noaa.gov/../cgi-bin/orca_prod_details.pl?3_CMBAD_NSandTData
[25]http://www-orca.nos.noaa.gov/projects/bioeffects/page1.html
[26]http://www-orca.nos.noaa.gov/../cgi-bin/orca_prod_details.pl?1_SEA_90-04
[27]http://www-orca.nos.noaa.gov/../cgi-bin/orca_prod_details.pl?1_SEA_92-06
[28]http://www-orca.nos.noaa.gov/../cgi-bin/orca_prod_details.pl?1_SEA_90-27

Program	Sponsor	Coverage	Frequency Most Recent Report
Month and State Current Emissions Trends	DOE Argonne National Laboratory	Emissions estimates for NOx, SO2, and VOCs by month and state from 1975 to the present for 68 emission source groups.	Monthly, 1975 to present; currently updating database; report forthcoming
National Energy Information Center	DOE Energy Information Administration	Collects, analyses, and publishes data on energy production, consumption, prices, and resources; projects energy supply and demand	Monthly, annual and special reports.[29]
Greenhouse Gas Emissions	DOE Energy Information Administration	Calculates and publishes annual estimates of U.S. greenhouse gas emissions (CO_2, methane, N_2O, and halocarbons as well as criteria pollutants (CO, NOx, and NMVOCs)	Annual; 1998 report with 1996 data.[30]
Voluntary Reporting of Greenhouse Gases	DOE Energy Information Administration	Publishes voluntarily reported data by U.S. individuals, corporations, and other organizations on actions taken to reduce the emissions of greenhouse gases; includes emissions, reductions, anticipated future reductions, and/or commitments to reduce greenhouse gases; maintains a "public use" database of relevant information.	Annual reports.[31]
Carbon Dioxide Information Analysis Center	DOE Oak Ridge National Laboratory	Compiles, evaluates, and distributes information related to carbon dioxide.	Data collection ranges from hourly to decadal; online access to data and reports.[32]
Integrated Data Base Program	DOE	Maintains data on all spent radioactive fuel and waste in the United States	Annual data collection and reporting.[33]

Notes:

[29] http://www.eia.doe.gov
[30] http://www.eia.doe.gov/environment.html
[31] http://www.eia.doe.gov/oiaf/1605/frntvrgg.html
[32] http://cdiac.esd.ornl.gov/pns/pns_main.html
[33] http://www.em.doe.gov/em30/idbrpts.html

Program	Sponsor	Coverage	Frequency Most Recent Report
National Wetlands Inventory	DOI FWS	Develops comprehensive information on the characteristics and extent of U.S. wetlands resources wetlands map coverage for 88% of lower 48 states 30% of Alaska, and all of Hawaii, Puerto Rico, and Guam	Wetlands trends reports for selected states[34, 35] and regions;[36] 1997 report with estimates of U.S. wetlands acreage for mid-1990s forthcoming
Gap Analysis	USGS Biological Resources Division	Develops standardized distribution maps of surface vegetation, terrestrial vertebrates, and endangered species in the lower 48 states and Hawaii	First national assessment to be completed in 1998; updates at 5-year intervals; annual bulletins[37]
Biomonitoring of Environmental Status and Trends (BEST)	USGS Biological Resources Division	Documents temporal and geographic trends in concentrations of persistent environmental contaminants that may threaten fish and wildlife; covers major U.S. rivers and Great Lakes	2-to-4 year intervals; intermittent reports[38]
North American Breeding Bird Survey	USGS Biological Resources Division	Provides uniform basis for assessing long-term trends in avian populations throughout North America; estimates number of individuals by species, survey route, and state	2-year intervals; 1997 report with results and analysis of 1966-1996 data[39]
Waterfowl Breeding Population and Habitat	DOI FWS	Provides annual breeding population estimates; measures breeding habitat changes over major portion of duck breeding range in North America	Annual surveys and reports[40]

Notes

[34]http://www.nwi.fws.gov/md.html
[35]http://www.nwi.fws.gov/texas.html
[36]http://www.nwi.fws.gov/sewet/index.html
[37]http://www.gap.uidaho.edu/gap/Bulletins/6/index.htm
[38]http://www.best.usgs.gov/reports.html
[39]http://www.mbr.nbs.gov/bbs/bbs.html
[40]http://www.fws.gov/r9mbmo/reports/status98/coversht.html

Program	Agency	Coverage	Frequency/ Most Recent Report
Status and Trends	USGS Biological Resources Division	Publishes reports on the status and trends of biological resources in the United States; publishes data on populations and habitats.	Periodic; Our Living Resources (1995); Status and Trends of the Nation's Biological Resources (forthcoming) [41]
Minerals Information	USGS Geologic Division	Collects, analyzes, and publishes data on metal and industrial minerals production and consumption, including scrap and waste.	Monthly, quarterly, and annually [42]
Public Land Statistics	BLM	Collects summary statistics of land ownership in the United States and BLM natural resource management programs at the state level.	Annual; 1997 report [43]
National Stream Quality Accounting Network (NASQAN) and National Hydrologic Benchmark Network (HBN)	USGS	NASQAN provides a national uniform basis for assessing large-scale, long-term trends in physical, chemical, and biological characteristics of waters; monitors for pH, alkalinity, sulfate, nitrate, phosphorus, calcium, magnesium, sodium, potassium, chloride, suspended sediment, fecal coliform and fecal streptococcal bacteria, dissolved oxygen, dissolved oxygen deficit, and trace elements. HBN monitors water quality in surface waters largely unaffected by human activities.	Yearly data summaries for each state; data on CD-ROM [44]

Notes

41 http://www.mp1-pwrc.usgs.gov/bpm/bsl.htm
42 http://minerals.er.usgs.gov/minerals/pubs/mcs/...html
43 http://www.blm.gov/natacq/pls97
44 http://wwwrvares.er.usgs.gov/wqn96cd

Program	Sponsor	Coverage	Frequency/ Most Recent Report
National Water Quality Assessment Program (NAWQA)	USGS Water Resources Division	Assesses historical, current, and future water quality conditions in representative river basins and aquifers nationwide.	Periodic reports; national synthesis for pesticides, nutrients, and volatile organic compounds.[45]
National Trends Network	USGS Water Resources Division	Monitors atmospheric deposition under National Atmospheric Deposition Program (NADP/NTN); 77 of 191 sites supported.	Annual updates; online data, maps, and reports.[46]
National Water Conditions Reporting System	USGS Water Resources Division	Collects and analyzes streamflow data, groundwater levels, reservoir contents, and limited water-quality data from 5 sites on major rivers.	Monthly; online.[47]
Water Data Program	USGS Water Resources Division	Nearly 60,000 water-data stations throughout the nation are used to obtain records on stream-flow, stage (height), reservoir and lake stage and storage, groundwater levels, well and spring discharge, and quality of surface water and groundwater. Data, stored in the WATSTORE database, are available in machine readable form or as computer printed tables or graphs, statistical analyses, and digital plots.	Published by water year for each state.[48]
National Water Use Information Program	USGS Water Resources	Determines purposes for U.S. fresh and saline surface water and groundwater withdrawn, water consumed during use; and water returned to source after use.	National compilations every 5 years,[49] preliminary data for 1995.[50]

Notes:

[45] http://wwwrvares.er.usgs.gov/nawqa/natsyn.html
[46] http://btdqs.usgs.gov/acidrain/
[47] http://water.usgs.gov/nwc/
[48] http://water.usgs.gov/public/data.html
[49] http://water.usgs.gov/public/watuse/wucircular2.html
[50] http://water.usgs.gov/public/watuse/prelimdoc.pdf

Program	Sponsor	Coverage	Frequency/ Most Recent Report
National Land Use and Cover Program	USGS National Mapping Division	Includes land-use and land-cover maps and digitized data. Statistics by political units, hydrologic units, and census county subdivisions are available. Classes include urban or built-up land, agricultural land, rangeland, forestland, water areas, wetland, barren land, tundra, and perennial snow and ice. Maps are available for most of the country at 1:250,000 scale.	Periodic; online status graphics; national atlas (in prep).[51]
National Earthquake Information Center	USGS Geologic Division	Determines locations and size of earthquakes worldwide; conducts research; disseminates information; maintains an extensive seismic database.	Daily; online.[52] Periodic reports.[53]
Earth Observing System	NASA	Measures key environmental variables using series of unmanned satellites; part of NASA *Mission to Planet Earth* program; EODIS, its data and information system, will coordinate with the Global Change Data and Information System, which includes the NOAA data and information system.	Periodic; reports and visual materials.[54]
National Air Pollution Control Program	EPA Office of Air Quality Planning and Standards	Collects and analyzes data on ambient air quality and compares pollution levels to National Ambient Air Quality Standards (NAAQS). Estimates criteria pollutant emissions from point, area, and mobile sources.	Annual reports on air quality[55] and emission estimates.[56]

Notes:

[51] http://www-atlas.usgs.gov/
[52] http://wwwneic.cr.usgs.gov/neis/bulletin/bulletin.html
[53] http://gldss7.cr.usgs.gov/neis/pANDs/title.html
[54] http://www.hq.nasa.gov/office/mtpe/education/
[55] http://www.epa.gov/oar/aqtrnd96/
[56] http://www.epa.gov/oar/emtrends.htm

Program	Sponsor	Coverage	Frequency/ Most Recent Report
Comprehensive Environmental Response, Compensation, and Liability Information System	EPA Office of Emergency and Remedial Response	Contains information on over 24,000 abandoned or uncontrolled hazardous waste sites.	Updated on-line.[57]
Environmental Radiation Ambient Monitoring System (ERAMS)	EPA Office of Radiation and Indoor Air	Monitors radiation in air, drinking water, surface water, and milk.	Sampling intervals from twice weekly to bi-annual, based on analyses, at 332 stations; quarterly reports since 1973;[58] most recent reports are for 1995.
Municipal Waste Survey	EPA Office of Solid Waste	Data about the composition and quantities generated and about quantities recycled and recycling methods.	Annual; 1997 with report with 1996 data.[59]
Hazardous Waste Survey	EPA Office of Solid Waste	Data about quantities generated and generators and aboutquantities managed, methods of management and disposal, and treatment and disposal facilities.	Biennial; current report contains 1995 data.[60]
Toxics Release Inventory	EPA Office of Pollution Prevention and Toxics	Mandatory annual inventory of releases of 643 toxic chemicals to air, water, land, and off-site disposal from more than 22,000 manufacturing facilities across the country (to be expanded to 28,000 facilities in 1998).	Annual reports and CD-ROM; current report contains 1996 data.[61]

Notes:

[57]http://www.epa.gov/superfund/oerr/siteinfo/index.htm
[58]http://www.epa.gov/narel/erdonline.html
[59]http://www.epa.gov.epa/epaoswer/non-hz/muncpl/msw97.htm
[60]http://www.epa.gov.epa/oswer/hazwaste/data/brs95/
[61]http://www.epa.gov/opptintr/tri/pubdat96.htm

Program	Sponsor	Coverage	Frequency/ Most Recent Report
Water Pollution Control Act Section 305 (b) Assessments	EPA Office of Water	Compiles state reports on water quality status of surface water and groundwater, as required by section 305 (b), Federal Water Pollution Control Act; the states prepare assessments using various monitoring data.	Biennial assessment and reporting; 1998 report with 1996 data.[62]
Ambient Water Monitoring Program/ STORET	EPA Office of Water	Largest database for water quality information with over 250 million data points from states and federal agencies on surface water and groundwater quality, sediments, streamflow, and fish tissue contamination.	Updated on-line.[63]
Public Water System Supervision Program	EPA Office of Water	Contains information about public water supplies (PWSs) and their compliance with monitoring requirements, maximum contaminant level (MCL) regulations, and other requirements of the Safe Drinking Water Act; data is stored in the Safe Drinking Water Information System.	Quarterly state and EPA regional reports; *1995 Community Water Systems Survey*;[64] 1996 annual compliance report.[65]
Index of Watershed Indicators	EPA Office of Water	Describes the condition and vulnerability to stressors for 2,11: watersheds in the continental United States (Alaska and Hawaii will be added later). Uses 15 different water resource indicators from a variety of federal, state, and private organizations. Information provided in text and map format.	Annual report; online maps.[66]

Notes:

[62]http://www.epa.gov/305b/index.html
[63]http://www.epa.gov/OWOW/STORET/
[64]http://www.epa.gov/OGWDW/cwssvr.html
[65]http://www.epa.gov/ogwdw/annual
[66]http://www.epa.gov/surf/

Program	Sponsor	Coverage	Frequency/ Most Recent Report
National Listing of Fish and Wildlife Consumption Advisory	EPA Office of Water	Database includes information on fish and wildlife consumption advisories issued by federal, state, tribal, and local governments	Annual report; 1997 update.[67]
National Sediment Inventory	EPA Office of Water	Mandated by the Water Resources Development Act of 1992, EPA compiles information on the quantity, chemical and physical composition, and geographic location of pollutants in aquatic sediment and identifies those that have been contaminated.	Biennial report; bi-annual newsletter.[68]
National Pollutant Discharge Elimination System Program	EPA Office of Water	Tracks permit compliance and enforcement status of facilities covered by water pollution permits; information is contained in the Permit Compliance System (PCS).	Monthly facility reports entered on an ongoing basis.
Municipal Construction Program	EPA Office of Water	Inventory of existing or proposed publicly owned treatment works (POTWs) that need construction or renovation to meet Clean Water Act requirements; information is maintained in the Needs Survey System.	2-year update from each state; biennial report submitted to the Congress; results of 1996 Needs Survey available in late 1997.
Coastal and Ocean Protection Programs	EPA Office of Water	Covers environmental data (water quality, biological, permitting, environmental impact data) for discharges and pollutant loadings to coastal waters as well as ocean dumping; information contained in Ocean Data Evaluation System (ODES).	Biennial reports to the Congress for National Estuary Program; annual reports to the Ocean Dumping Program; special reports on coastal programs; quarterly bulletin.[69]

Notes:

[67] http://www.epa.gov/OST/fishadvice
[68] http://www.epa.gov/docs/ostwater/Events/csnews20.htm
[69] http://www.epa.gov/OWOW/estuaries/nep.html

Program	Sponsor	Coverage	Frequency/ Most Recent Report
National Marine Debris Monitoring Program	EPA Office of Water	Assess the amounts and sources of marine debris on the nation's coastlines. Uses scientifically designed protocol and tracks 30 indicator items. Status and trends of the various indicator items will be analyzed on a local, regional and national scale.	Report expected in 2005.

Source: U.S. Environmental Protection Agency, Center for Environmental Statistics, *A Guide to Selected National Environmental Statistics in the U.S. Government* (Washington, DC: EPA, 1993) and updates by agencies.

Notes: Neither this table nor the source document, which describes 72 federal programs, are exhaustive. For instance, USDA also maintains mission-oriented statistics in such areas as crops, snowpack, soil erosion, national forests management, and wildfires. The DOC Bureau of Census maintains social, demographic, and economic statistics relevant to the environment. NOAA maintains statistics on marine resources and coastal wetlands. BLM maintains statistics for BLM lands, including condition, wildlife, minerals, and use; and NPS collects comparable statistics on the status of national parks. The Bureau of Mines collects, interprets, and publishes data on production, consumption, and trade of over 100 minerals. FWS maintains data on FWS lands and conducts surveys of fishing, hunting, and wildlife-associated recreation every 5 years, with the most recent report in 1991. USGS maps national land use and land cover, and EPA conducts regional and other pollution surveys. DOT compiles highway and other transportation statistics, and the U.S. Coast Guard maintains data on marine pollution spills.

Abbreviations:

BLM = Bureau of Land Management, Department of Interior
CEQ = President's Council on Environmental Quality
COE = U.S. Department of Defense, Army Corps of Engineers
DOC = U.S. Department of Commerce
DOE = U.S. Department of Energy
DOI = U.S. Department of the Interior
EC = European Community
EPA = U.S. Environmental Protection Agency
FAO = United Nations Food and Agriculture Organization
FWS = Fish and Wildlife Service, Department of the Interior
NASA = National Aeronautics and Space Administration
NOAA = National Oceanic and Atmospheric Administration, Department of Commerce
OMB = President's Office of Management and Budget
OSTP = President's Office of Science and Technology Policy
RPA = Forest and Rangeland Renewable Natural Resources Policy Act
USDA = U.S. Department of Agriculture
USGS = U.S. Geological Survey, Department of the Interior

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